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WATER DISTRIBUTION FROM AN ARRAY OF FOUR SPRINKLERS

by

R. A. Young and A. Lange

May 1970

FIRE RESEARCH STATION

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SUMMARY

The distribution of water at depths of 0.61, 1.22 and 3.66 m (2, 4 and 12 feet) beneath a square array of four similar sprinklers operating at a pressure of 0.70 kgf/cm^2 (10 lb/sq.in) and spaced to give a coverage of 12.08 m^2 (130 ft^2) per head, has been measured. Five makes of conventional and spray sprinklers, both upright and pendent, have been examined in this way, a total of 23 different sprinkler types and positions.

The uniformity of distribution over the central part of the square collecting area beneath the array has been assessed from 25 per cent and 100 per cent samples, in order to provide the basis for developing a method of approval of sprinkler distribution.

KEY WORDS: Distribution, Measurement, Sprinkler, Water.

MINISTRY OF TECHNOLOGY AND FIRE OFFICES' COMMITTEE
JOINT FIRE RESEARCH ORGANIZATION

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1. INTRODUCTION

An examination of the distribution of water from groups of four similar sprinklers has been made to determine the effect of the variables of sprinkler make, type and mounting position on the uniformity of the water distribution over an area of 12.08 m^2 (130 ft^2). The four sprinklers were mounted each at the corner of a square array of side 3.48 m (11.4 ft), so that each sprinkler had a nominal coverage of 12.08 m^2 (130 ft^2). Five makes of sprinkler were used, in spray and conventional forms, mounted in the upright and/or pendent positions. The water distributions were measured in horizontal planes at distances of 0.61 m (2 ft), 1.22 m (4 ft) and 3.66 m (12 ft) below the sprinklers, at an inlet water pressure to the array of 0.70 kgf/cm^2 (10 lbs/in^2). The object of this study was to provide a basis for the regular examination and approval of the uniformity of water distribution from the arrays of sprinklers of various types submitted for approval by the Fire Offices' Committee.

2. EXPERIMENTAL

The experimental variables examined in the programme were as follows:-

(a) Sprinkler array

The sprinklers were mounted at the corners of a square of side 3.48 m (11.4 x 11.4 ft). The arrangement of pipework, which is shown in Fig 1, conformed to the Fire Offices' Committee rules. The array was mounted beneath a 6.10 m (20 ft) square ceiling, so that the centre of the square and the centre of the ceiling were coaxial.

(b) Five makes of sprinkler were tested, and have been designated P, Q, R, S and T. The orifice diameters of the sprinklers was the same for all sprinklers of each make, but varied between the makes, as shown in Table 1.

(c) Types of sprinkler tested:

(i) Conventional, for mounting in either upright or pendent positions

(ii) Upright spray

(iii) Pendent spray

(d) Mounting position:

(i) Upright, deflector plate 76 mm (3 in) below ceiling

(ii) Pendent, deflector plate 305 mm (12 in) below ceiling

(e) Water pressure: 0.70 kgf/cm^2 (10 lbf/in^2), measured by a pressure gauge at the point in the main distribution pipe shown in Fig 1.

(f) Distance of sprinklers above buckets:

This is the vertical distance between the sprinkler deflector plates and the plane of the tops of the buckets.

Nominal distance	Sprinkler position	Actual distance below sprinkler deflector plate	
ft		m	ft-in
2	Upright	0.72	2 - 4½
2	Pendent	0.50	1 - 7½
4	Upright	1.22	4 - 0
4	Pendent	1.22	4 - 0
12	Upright	3.64	11 - 11½
12	Pendent	3.41	11 - 2½

The water discharge from the sprinkler array was collected in plastic buckets, each with a mouth 279 mm (11 in) square. The buckets were arranged as shown in Fig 2, so that each was at the centre of a 0.61 m x 0.61 m (2 ft x 2 ft) square, except that at the central 1.52 m x 1.52 m (5 ft x 5 ft), the buckets were placed in contact to give complete coverage of that part of the area. In each experiment, the water was discharged from the sprinklers for 10 minutes at a pressure of 0.70 kgf/cm^2 (10 lbf/in^2). The quantity of water in each bucket was measured and the rate of water deposition per unit area for each collecting point was calculated. The weighting given for each collecting point is given in Fig 3. Two replications were made for each combination of the experimental variables.

To measure the discharge from each of the sprinklers, four of each make and type were mounted in turn in the pendent position, and a large diameter hose was used to feed the discharge from each into one of four 90.9 litre (20 gallon) containers. The total sum of the discharges from each of the four sprinklers was divided by four to give a measure of the discharge in the 12.08 m^2 (130 ft^2) collecting area, as shown in Table 2.

3. RESULTS

The rates of water deposition per unit area were plotted for each of the experimental conditions, taking a mean value for the two replications, which showed close agreement. The results were plotted on a grid representing the individual collecting points, using circles of various sizes to represent ranges of deposition rates per unit area of 0.04 - 0.08 : 0.08 - 0.16 : 0.16 - 0.33 : 0.33 - 0.49 : 0.49 - 0.65 : and 0.65 lm^{-2} s^{-1} (0.05 - 0.1 : 0.1 - 0.2 : 0.2 - 0.4 : 0.4 - 0.6 : 0.6 - 0.8 : and 0.8 gal ft^{-2} min^{-1}). A blank space represents a rate of discharge of less than 0.04 lm^{-2} s^{-1} (0.05 gal ft^{-2} min^{-1}). The complete results are given in Appendix I.

In considering the effects of the different variables, four measures of flow rate and water distribution were used as follows:

(a) Mean <u>measured</u> rate of deposition per unit area over the total 12.08 m^2 (130 ft^2) projected area.

This quantity was calculated from the mean of the measured flows from the four sprinklers, as described above, divided by the total projected area of 12.08 m^2 (130 ft^2). The values appropriate to each make and type of sprinkler are given in Table 2, cols (4) and (5).

(b) Mean <u>estimated</u> rate of deposition per unit area, over the total 12.08 m^2 (130 ft^2) projected area.

This quantity was calculated by measuring the rate of discharge into each bucket, multiplying the result by the area 'represented' by the bucket, adding all the results and dividing by the total area. The values for each make and type of sprinkler are given in Table 2, cols (6) to (11), for the three collecting heights. The areas 'represented' by each bucket are shown in Fig 2.

(c) Mean <u>estimated</u> rate of deposition per unit area, over the central 3.32 m^2 (25 ft^2) area.

This was calculated as for (b) above, except that all buckets had the same area representation. The values for each make and type of sprinkler are given in Table 3, cols (4) to (9), for the three collecting heights.

(d) Percentage of <u>total</u> area receiving less than selected rates of deposition per unit area.

This was calculated by observing those buckets in which the rate of deposition lay below a specific value, and estimating the percentage of the total area 'represented' by these buckets. The specified values were 0.041, 0.057, 0.061 and 0.082 lm^{-2} s^{-1} (0.05, 0.07, 0.075 and 0.10 gal ft^{-2} min^{-1}) respectively. The value 0.061 lm^{-2} s^{-1} (0.075 gal ft^{-2} min^{-1}) is

significant in that it represents the minimum practicable value for curtailing the growth of carbonaceous fires of heights of about 1 m (3 ft) from floor level[1]. The percentage for each make and type of sprinkler are given in Table 4.

A comparison was made between results obtained by sampling from all 25 buckets in the central area, and from the nine marked buckets shown in Fig 3. The results are shown in Table 5, where the columns (a) give the mean rate of deposition per unit area calculated from results for all 25 buckets, and columns (b) from the results for the nine marked buckets. The difference between these rates was shown to be small.

Table 6 gives the average values, taken over all makes of sprinkler, for spray and conventional, upright and pendent types, of the mean estimated water deposition for the central area, based on 25 points.

The ratio X of $\frac{\text{mean estimated rate for central area}}{\text{mean estimated rate for total area}}$ is given in Table 7. For an even distribution this ratio should be unity. When it is less than unity a higher proportion of water is falling outside the central area, and vice versa.

The mean value of the ratio X was calculated for each group of sprinklers, as a guide to the uniformity of the distribution.

Sprinkler group	Ratio X
Upright spray	0.85
Pendent spray	0.71
Upright conventional	0.51
Pendent conventional	0.72

Using this ratio as a measure, the distribution from conventional sprinklers in the upright position is markedly less uniform than for the other three groups.

4. CONCLUSIONS

(a) Mean density of water distribution

This is mainly dependent upon the total rate of discharge from the four sprinkler heads, at the inlet pressure of 0.70 kgf/cm^2 (10 lbf/in^2). The mean density of distribution over the 12.08 m^2 (130 ft^2) area, varied from 0.082 $lm^{-2}\ s^{-1}$ (0.1 gal $ft^{-2}\ min^{-1}$) to 0.102 $lm^{-2}\ s^{-1}$ (0.124 gal $ft^{-2}\ min^{-1}$).

(b) Uniformity of distribution

As the distance of the collecting cans below the sprinklers increased, the distribution became more uniform. In general, the uniformity of distribution increased substantially up to 4 feet below the sprinklers, but there was little change between 4 and 12 feet. It is concluded that, for the best results, sprinklers should be not less than 4 feet above the goods they protect.

Upright conventional sprinklers gave a noticeably less uniform distribution than the other three types at all levels. There was little difference in uniformity between the pendent conventional sprinklers and the upright and pendent spray sprinklers. This conclusion is based on 5 samples in each case.

Some makes of sprinkler gave more uniform distribution than other makes, but generally the differences were small.

(c) Measurement techniques

For the central area, a collecting area of 20 per cent of the total is probably sufficient to give accurate results, but this may not be true for parts of the total area near to the sprinkler mounting position, especially at the 0.61 m (2 ft) and 1.2 m (4 ft) levels. Consideration of a simple method of 100 per cent sampling of the whole area would probably be profitable.

REFERENCE

(1) M.J. O'DOGHERTY, P. NASH, R.A. YOUNG., Fire Research Technical Paper No. 17. Her Majesty's Stationery Office, 1967.

TABLE 1

MEAN ORIFICE DIAMETERS

MAKE	MINIMUM DIAMETER	
	cm	in
P	1.10	0.435
Q	1.12	0.440
R	1.27	0.500
S	1.12	0.440
T	1.22	0.480

TABLE 2

Mean measured and estimated rate of discharge per unit area

	Make	Type	Position	Mean measured rate of discharge		Mean estimated rate of discharge					
						0.61 m (2 ft)		1.2 m (4 ft)		3.66 m (12 ft)	
				$lm^{-2}s^{-1}$	gal $ft^{-2}min^{-1}$	$lm^{-2}s^{-1}$	gal $ft^{-2}min^{-1}$	$lm^{-2}s^{-1}$	gal $ft^{-2}min^{-1}$	$lm^{-2}s^{-1}$	gal $ft^{-2}min^{-1}$
1	P	Spray	Upright	0.083	0.101	0.084	0.102	0.081	0.099	0.068	0.083
2	Q	"	"	0.086	0.105	0.079	0.097	0.077	0.094	0.066	0.081
3	Q	"	"	0.085	0.103	0.080	0.098	0.081	0.099	0.063	0.077
4	R	"	"	0.101	0.123	0.103	0.127	0.099	0.121	0.095	0.116
5	S	"	"	0.085	0.104	0.088	0.107	0.082	0.100	0.078	0.095
6	T	"	"	0.095	0.116	0.082	0.100	0.079	0.096	0.073	0.089
7	P	"	Pendent	0.085	0.103	0.085	0.103	0.085	0.104	0.080	0.098
8	Q	"	"	0.085	0.104	0.095	0.116	0.084	0.102	0.087	0.106
9	Q	"	"	0.085	0.104	0.095	0.116	0.085	0.104	0.071	0.087
10	R	"	"	0.098	0.119	0.102	0.125	0.102	0.125	0.103	0.126
11	S	"	"	0.084	0.102	0.079	0.097	0.079	0.097	0.082	0.100
12	T	"	"	0.100	0.122	0.103	0.126	0.098	0.119	0.098	0.119
13	P	Conventional	Upright	0.085	0.103	0.076	0.093	0.064	0.080	0.085	0.104
14	Q	"	"	0.086	0.105	0.074	0.090	0.073	0.089	0.085	0.103
15	R	"	"	0.102	0.124	0.053	0.065	0.059	0.072	0.102	0.124
16	S	"	"	0.084	0.102	0.066	0.080	0.053	0.064	0.059	0.072
17	T	"	"	0.082	0.100	0.064	0.078	0.062	0.076	0.081	0.099
18	P	"	Pendent	0.085	0.103	0.089	0.109	0.082	0.100	0.085	0.103
19	Q	"	"	0.086	0.105	0.084	0.102	0.083	0.101	0.083	0.101
20	R	"	"	0.102	0.124	0.103	0.126	0.097	0.118	0.102	0.124
21	S	"	"	0.084	0.102	0.084	0.102	0.091	0.111	0.087	0.106
22	T	"	"	0.082	0.100	0.084	0.102	0.084	0.102	0.087	0.106
23	Q	"	"	0.085	0.103	0.089	0.109	0.085	0.103	0.085	0.104

Table 3

Mean estimated rate of discharge per unit area for central 2.32 m^2 (25 ft^2)

Make	Type	Position	DISCHARGE PER UNIT AREA FOR CENTRAL 2.32 m^2 (25 ft^2)					
			0.61 m (2 ft)		1.2 m (4 ft)		3.66 m (12 ft)	
			$lm^{-2}s^{-1}$	gal $ft^{-2}min^{-1}$	$lm^{-2}s^{-1}$	gal $ft^{-2}min^{-1}$	$lm^{-2}s^{-1}$	gal $ft^{-2}min^{-1}$
P	Spray	Upright	0.075	0.092	0.125	0.152	0.078	0.095
Q	"	"	0.033	0.040	0.066	0.080	0.060	0.073
Q	"	"	0.051	0.062	0.100	0.122	0.063	0.077
R	"	"	0.053	0.065	0.085	0.103	0.101	0.124
S	"	"	0.039	0.048	0.075	0.091	0.085	0.104
T	"	"	0.027	0.033	0.039	0.048	0.078	0.095
P	"	Pendent	0.093	0.114	0.101	0.123	0.067	0.082
Q	"	"	0.016	0.019	0.075	0.091	0.057	0.070
Q	"	"	0.011	0.013	0.089	0.109	0.081	0.099
R	"	"	0.022	0.026	0.095	0.116	0.136	0.166
S	"	"	0.018	0.022	0.054	0.066	0.106	0.130
T	"	"	0.004	0.005	0.016	0.019	0.081	0.099
P	Conventional	Upright	0.027	0.033	0.051	0.062	0.080	0.098
Q	"	"	0.037	0.045	0.053	0.065	0.058	0.071
R	"	"	0.013	0.016	0.018	0.022	0.043	0.052
S	"	"	0.013	0.016	0.025	0.030	0.039	0.048
T	"	"	0.020	0.024	0.027	0.033	0.040	0.049
P	"	Pendent	0.053	0.065	0.080	0.098	0.073	0.089
Q	"	"	0.050	0.061	0.089	0.108	0.069	0.084
R	"	"	0.008	0.010	0.038	0.046	0.125	0.152
S	"	"	0.012	0.014	0.041	0.050	0.108	0.131
T	"	"	0.011	0.013	0.049	0.060	0.125	0.152
Q	"	"	0.024	0.029	0.090	0.110	0.088	0.107

TABLE 4

Percentage of total area with rates of discharge below fixed values

	Make	Type	Position	Percentage of total area below fixed rates of discharge																					
				0.61 m (2 ft) level							1.2 m (4 ft) level							3.66 m (12 ft) level							
				0	0.020	0.041	0.061	0.082	0.102	0.123	0	0.020	0.041	0.061	0.082	0.102	0.123	0	0.020	0.041	0.061	0.082	0.102	0.123	$lm^{-2}s^{-1}$
				0	0.025	0.050	0.075	0.100	0.125	0.150	0	0.025	0.050	0.075	0.100	0.125	0.150	0	0.025	0.050	0.075	0.100	0.125	0.150	gal $ft^{-2}min^{-1}$
1	P	Spray	Upright		2	5	24	45	92	92		5	12	28	38	95	95				39	76	100	100	
2	Q	"	"		6	19	49	60	70	92			5	30	55	87	90				40	66	94	97	
3	Q	"	"	2	9	17	38	60	75	75		2	15	37	49	81	90				38	97	100	100	
4	R	"	"			2	22	32	57	75				7	38	65	82					15	82	98	
5	S	"	"		2	10	30	48	66	79			7	31	55	82	87				23	58	98	98	
6	T	"	"		12	33	44	68	70	73			29	55	62	79	85				48	67	92	98	
7	P	"	Pendent				21	53	88	90		3	10	37	54	85	93			5	30	78	91	91	
8	Q	"	"	9	23	39	53	58	60	86			19	43	59	73	81				24	50	84	97	
9	Q	"	"	10	23	32	53	64	69	69			13	34	51	60	85				36	70	97	97	
10	R	"	"	5	17	35	48	52	58	68		7	12	22	35	62	70			2	9	22	41	67	
11	S	"	"	3	24	46	53	65	70	72		5	10	33	50	76	87		2	9	20	25	73	93	
12	T	"	"	26	38	51	66	75	80	80		27	49	49	59	67	67				22	48	61	71	
13	P	Conventional	Upright		17	35	64	70	80	86		5	22	44	75	85	92				10	41	90	90	
14	Q	"	"		6	26	50	66	80	90			13	34	72	79	84				52	77	87	87	
15	R	"	"		25	53	67	77	90	92		13	52	67	75	82	87			9	64	77	79	79	
16	S	"	"		26	44	56	65	85	88		5	41	78	87	90	97			23	77	82	87	87	
17	T	"	"		21	43	65	70	80	85			53	64	77	82	84			13	64	78	82	87	
18	P	"	Pendent		3	10	38	61	73	82				16	52	90	93				17	56	82	95	
19	Q	"	"			10	39	57	77	87			4	29	47	76	90				16	56	89	95	
20	R	"	"	6	27	37	51	54	62	70			10	33	41	57	66				15	25	59	64	
21	S	"	"		30	46	61	62	72	78			12	40	53	69	72				18	48	63	83	
22	T	"	"	5	25	44	57	62	70	75			21	44	55	60	72				12	48	82	86	
23	Q	"	"	4	13	26	52	66	72	77			5	11	48	77	93				8	36	90	95	

TABLE 5

Comparison of measurement method for central area

	Make	Type	Position	Mean discharge per unit area for central 2.32 m^2 (25 ft^2)											
				0.61 m (2 ft)				1.2 m (4 ft)				3.66 m (12 ft)			
				$lm^{-2}s^{-1}$	gal $ft^{-2}min^{-1}$	$lm^{-2}s^{-1}$	gal $ft^{-2}min^{-1}$	$lm^{-2}s^{-1}$	gal $ft^{-2}min^{-1}$	$lm^{-2}s^{-1}$	gal $ft^{-2}min^{-1}$	$lm^{-2}s^{-1}$	gal $ft^{-2}min^{-1}$	$lm^{-2}s^{-1}$	gal $ft^{-2}min^{-1}$
				25 Points (a)		9 Points (b)		25 Points (a)		9 Points (b)		25 Points (a)		9 Points (b)	
1	P	Spray	Upright	.075	.092	.081	.099	.125	.152	.106	.130	.078	.095	.076	.093
2	Q	"	"	.033	.040	.039	.048	.066	.080	.065	.079	.060	.073	.060	.073
3	Q	"	"	.051	.062	.044	.053	.100	.122	.090	.109	.063	.077	.064	.078
4	R	"	"	.053	.065	.058	.071	.085	.103	.083	.101	.101	.124	.106	.130
5	S	"	"	.039	.048	.045	.054	.075	.091	.073	.089	.085	.104	.085	.104
6	T	"	"	.027	.033	.030	.037	.039	.048	.042	.051	.078	.095	.076	.093
7	P	"	Pendent	.093	.114	.089	.108	.101	.123	.097	.118	.067	.082	.068	.082
8	Q	"	"	.016	.019	.028	.034	.075	.091	.070	.086	.057	.070	.059	.072
9	Q	"	"	.011	.013	.022	.027	.089	.109	.084	.103	.081	.099	.077	.094
10	R	"	"	.022	.026	.026	.032	.095	.116	.104	.127	.136	.166	.137	.167
11	S	"	"	.018	.022	.020	.024	.054	.066	.058	.071	.106	.130	.110	.134
12	T	"	"	.004	.005	.008	.010	.016	.019	.018	.022	.081	.099	.083	.101
13	P	Conventional	Upright	.027	.033	.031	.038	.051	.062	.052	.063	.080	.098	.081	.100
14	Q	"	"	.037	.045	.039	.048	.053	.065	.056	.068	.058	.071	.060	.073
15	R	"	"	.013	.016	.015	.018	.018	.022	.020	.024	.043	.052	.044	.053
16	S	"	"	.013	.016	.016	.019	.025	.030	.027	.033	.039	.048	.040	.049
17	T	"	"	.020	.024	.020	.024	.027	.033	.026	.032	.040	.049	.042	.051
18	P	"	Pendent	.053	.065	.057	.070	.080	.098	.079	.096	.073	.089	.074	.090
19	Q	"	"	.050	.061	.050	.061	.089	.108	.085	.104	.069	.084	.071	.086
20	R	"	"	.008	.010	.009	.012	.038	.046	.043	.052	.125	.152	.121	.148
21	S	"	"	.012	.014	.014	.017	.041	.050	.049	.060	.108	.131	.101	.123
22	T	"	"	.011	.013	.014	.017	.049	.060	.055	.067	.125	.152	.114	.139
23	Q	"	"	.024	.029	.031	.038	.090	.110	.089	.108	.088	.107	.085	.104

Table 6

Mean rate of discharge for central area - comparison of sprinkler types

Type	Position	DISCHARGE PER UNIT AREA FOR CENTRAL 2.32 m^2 (25 ft^2)							
		0.61 m (2 ft)		1.22 m (4 ft)		3.66 m (12 ft)		All levels	
		$lm^{-2}s^{-1}$	gal $ft^{-2}min^{-1}$	$lm^{-2}s^{-1}$	gal $ft^{-2}min^{-1}$	$lm^{-2}s^{-1}$	gal $ft^{-2}min^{-1}$	$lm^{-2}s^{-1}$	gal $ft^{-2}min^{-1}$
Spray	Upright	0.047	0.057	0.081	0.099	0.078	0.095	0.069	0.084
Spray	Pendent	0.027	0.033	0.071	0.087	0.089	0.108	0.062	0.076
Conventional	Upright	0.018	0.022	0.029	0.035	0.044	0.053	0.036	0.044
Conventional	Pendent	0.026	0.032	0.065	0.079	0.098	0.119	0.063	0.077

Table 7

Values of Ratio 'X' for each collecting level

	Make	Type	Position	Collecting Level		
				(2 ft) 0.61 m	(4 ft) 1.22 m	(12 ft) 3.66 m
1	P	Spray	Upright	0.90	1.54	1.14
2	Q	"	"	0.41	0.85	0.90
3	Q	"	"	0.63	1.23	1.00
4	R	"	"	0.51	0.85	1.07
5	S	"	"	0.45	0.91	1.09
6	T	"	"	0.33	0.50	1.06
7	P	Spray	Pendent	1.12	1.18	0.84
8	Q	"	"	0.16	0.89	0.66
9	Q	"	"	0.11	1.08	1.14
10	R	"	"	0.21	0.93	1.32
11	S	"	"	0.23	0.67	1.30
12	T	"	"	0.04	0.16	0.83
13	P	Conventional	Upright	0.35	0.78	0.94
14	Q	"	"	0.50	0.73	0.69
15	R	"	"	0.25	0.33	0.42
16	S	"	"	0.20	0.47	0.67
17	T	"	"	0.34	0.44	0.50
18	P	Conventional	Pendent	0.60	0.98	0.91
19	Q	"	"	0.60	1.07	0.83
20	R	"	"	0.08	0.39	1.23
21	S	"	"	0.13	0.45	1.23
22	T	"	"	0.13	0.59	1.43
23	Q	"	"	0.26	1.07	1.03

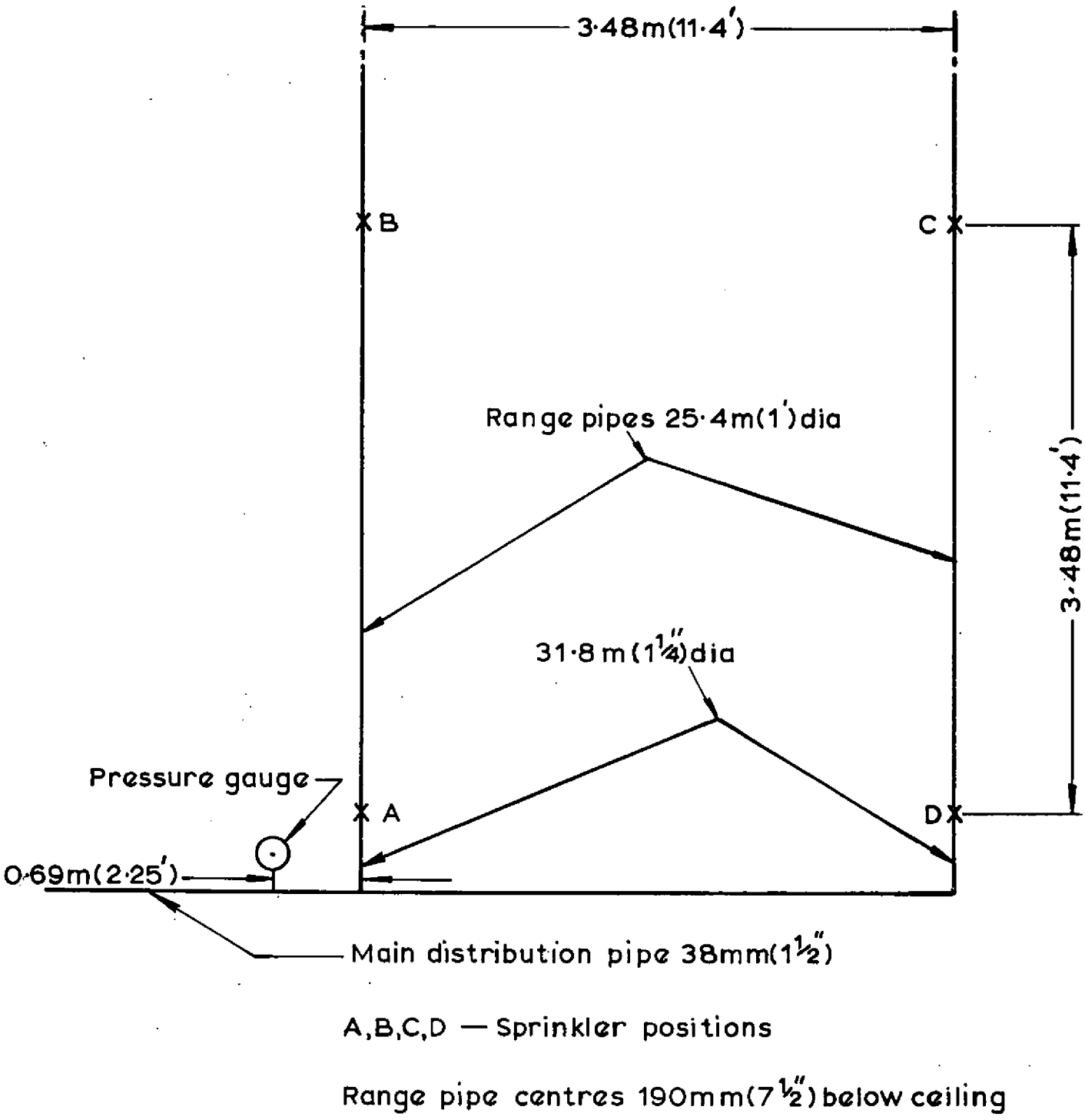
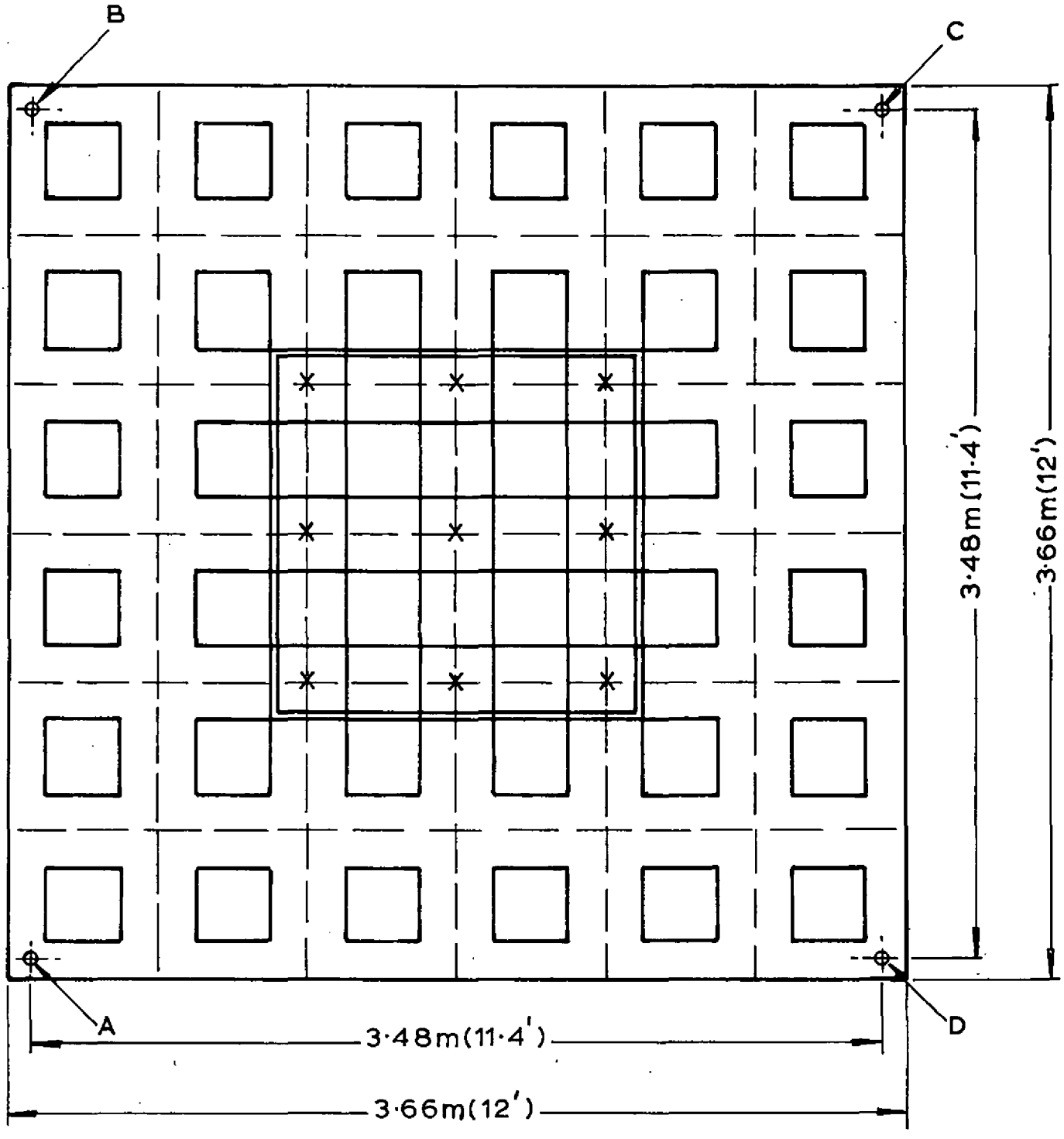


FIG.1 ARRANGEMENT OF SPRINKLER PIPEWORK



A,B,C,D — Sprinkler positions

FIG.2 ARRANGEMENT OF COLLECTING BUCKETS

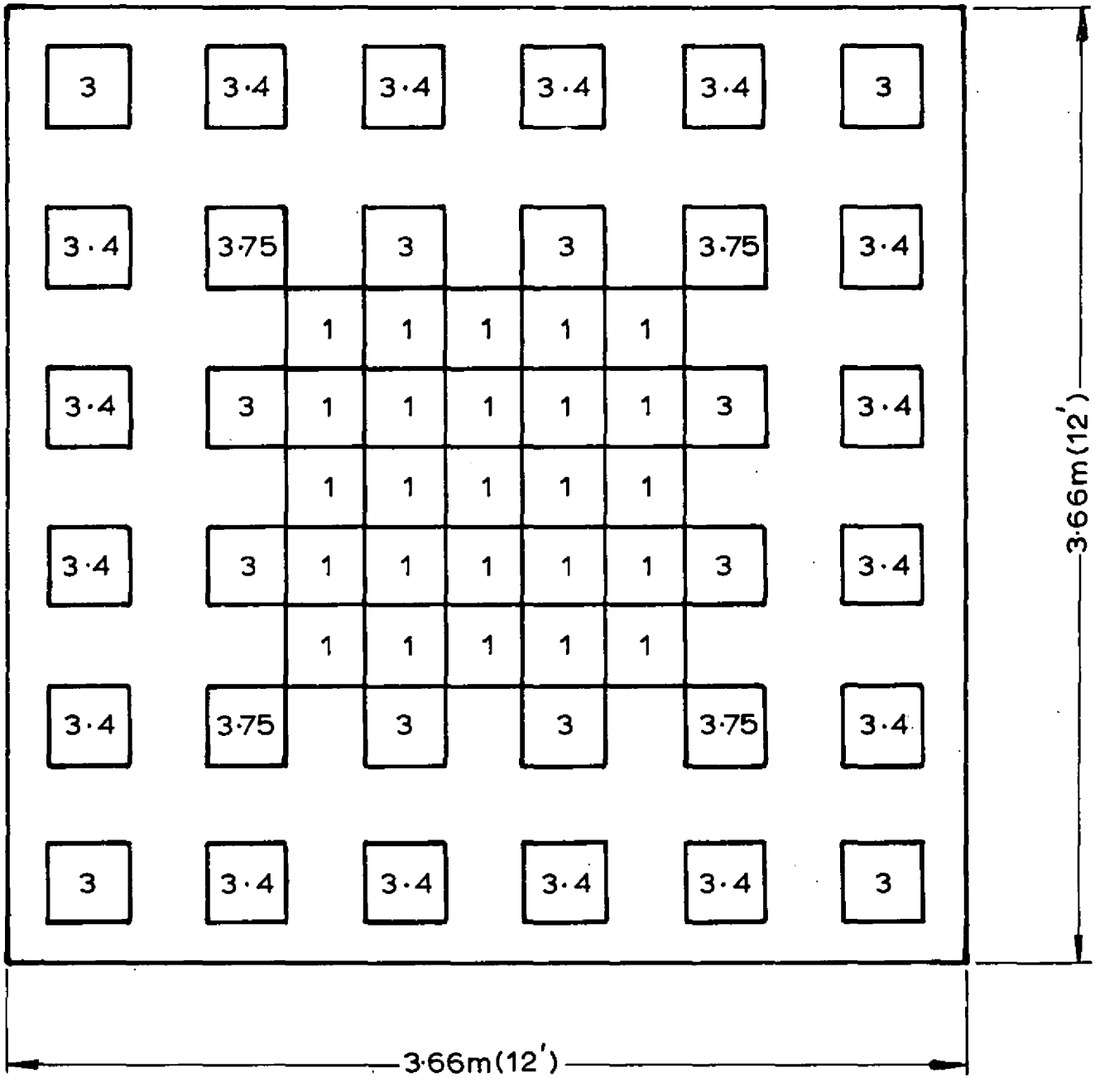
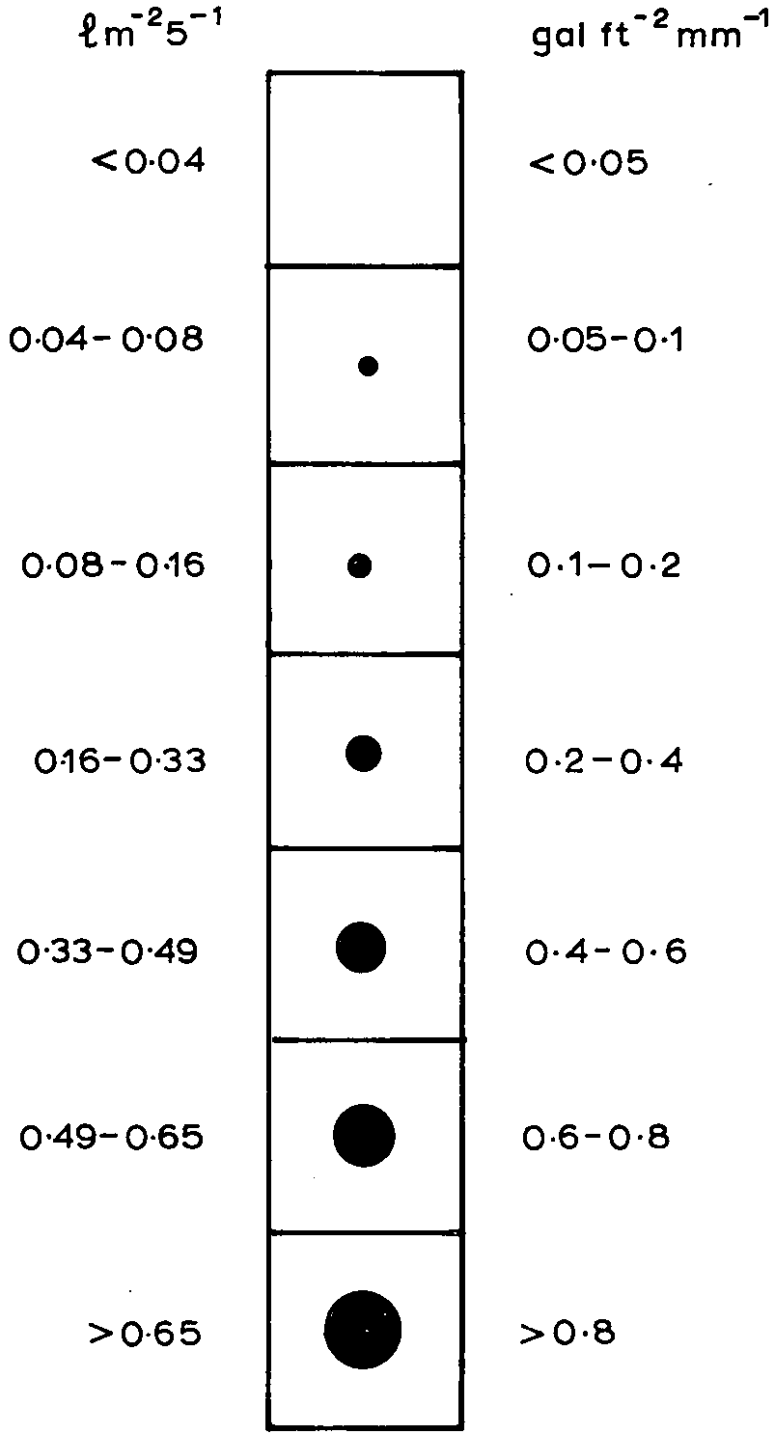
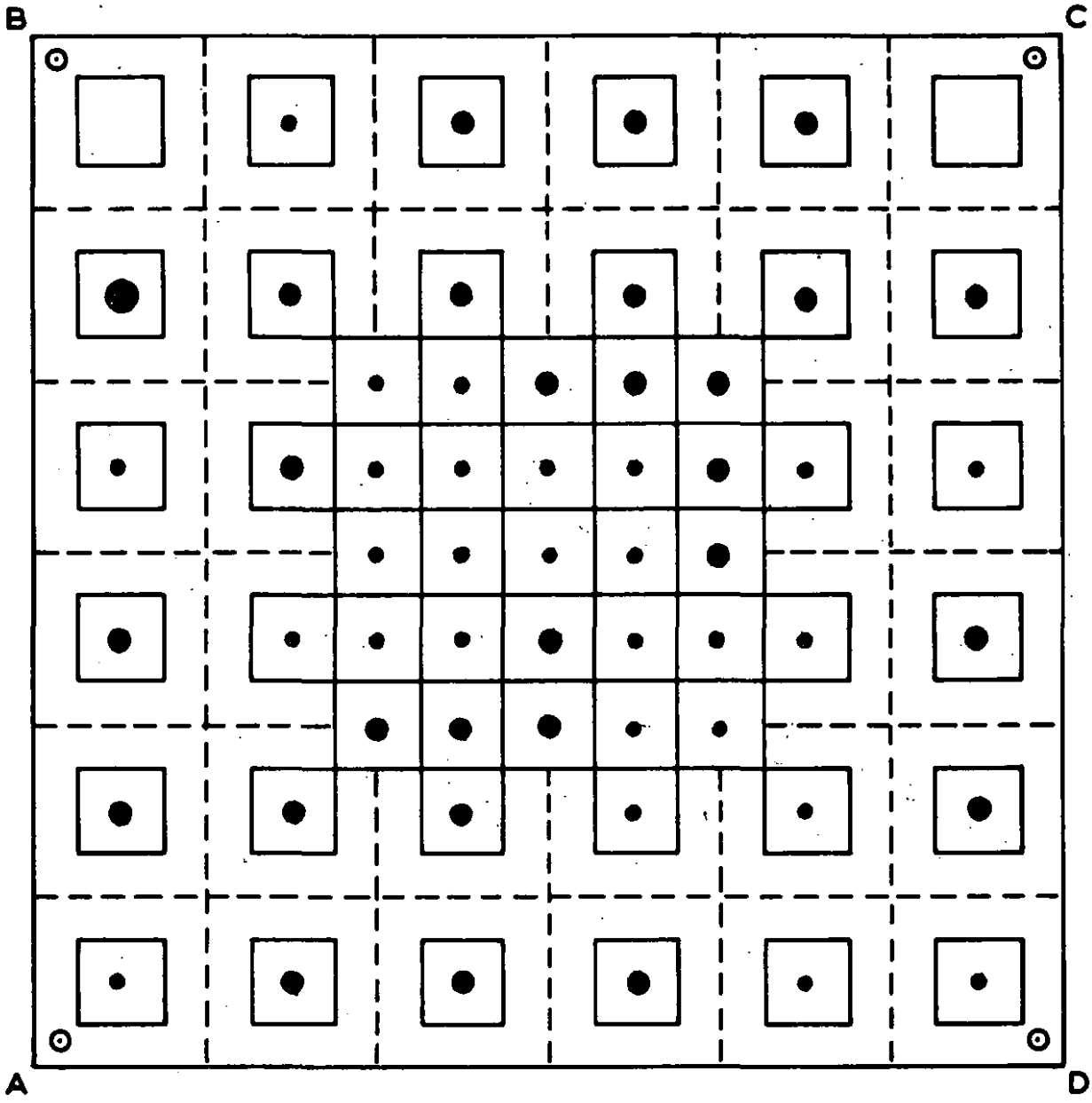


FIG.3 WEIGHTING GIVEN TO BUCKETS UNDER ARRAY



APPENDIX 1 WATER DISTRIBUTION

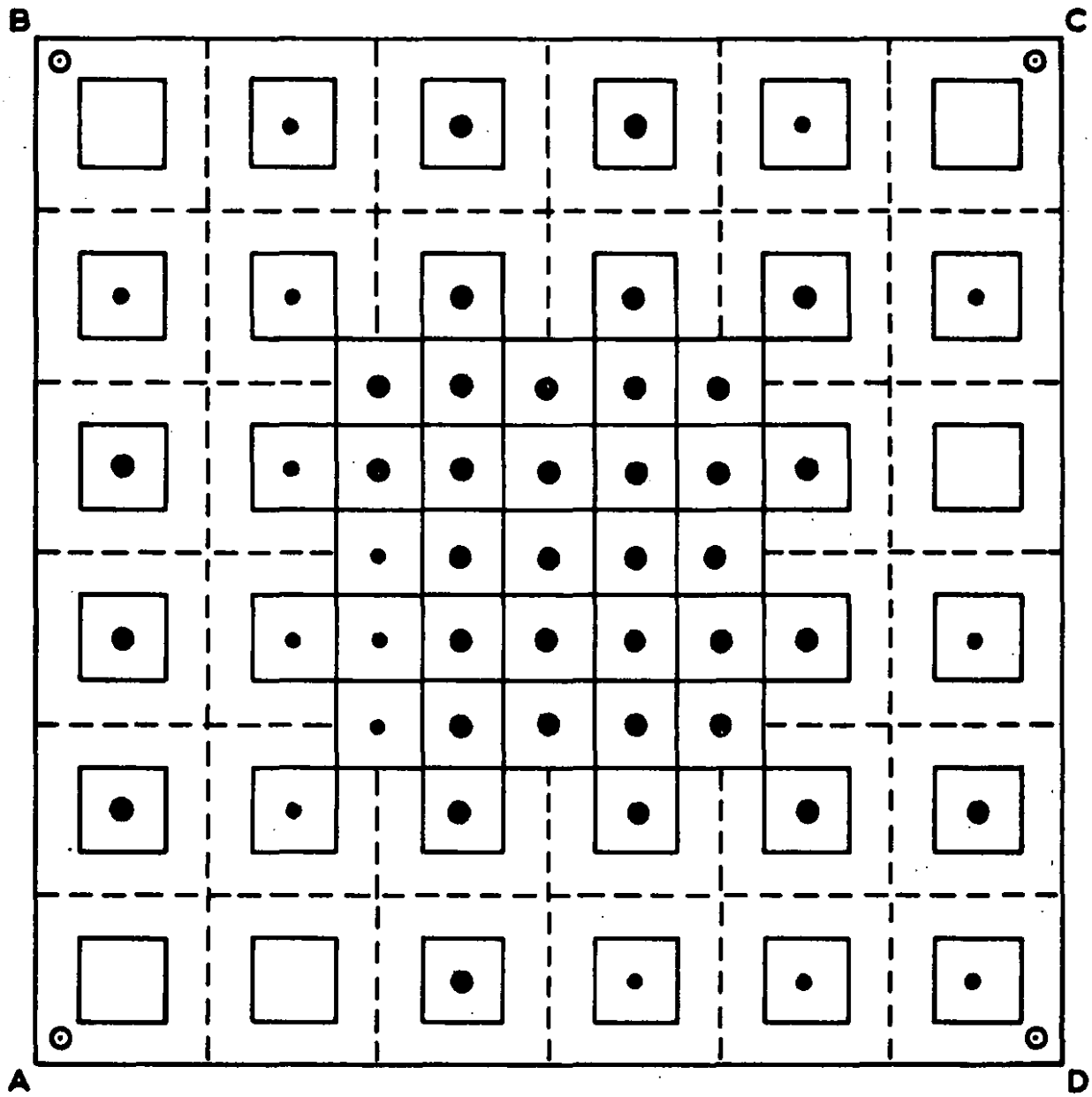


Make P

Type SPRAY, UPRIGHT

Level 2 ft.

Distribution number 1 a

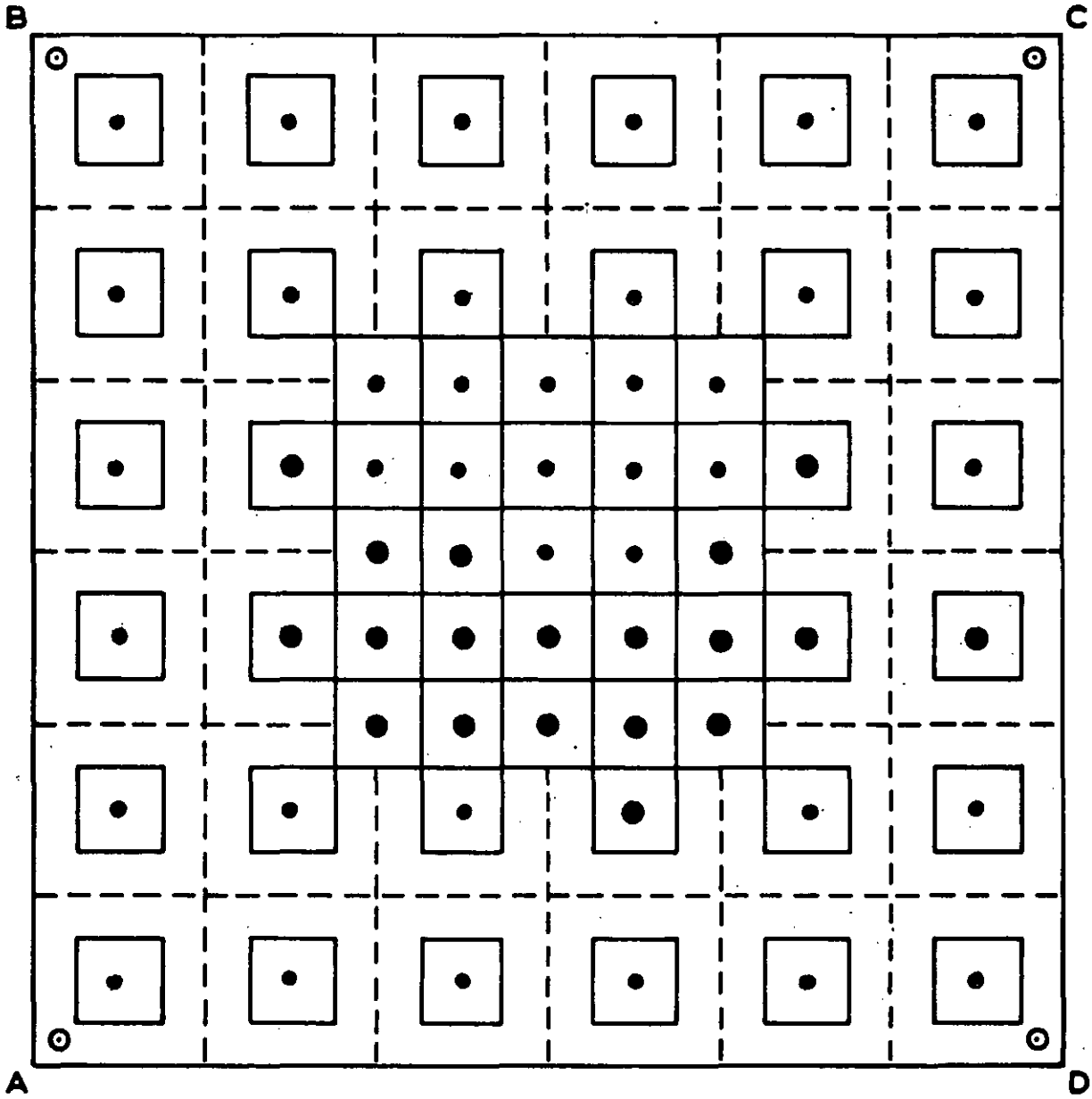


Make P.

Type SPRAY, UPRIGHT

Level 4 ft.

Distribution number 1 b

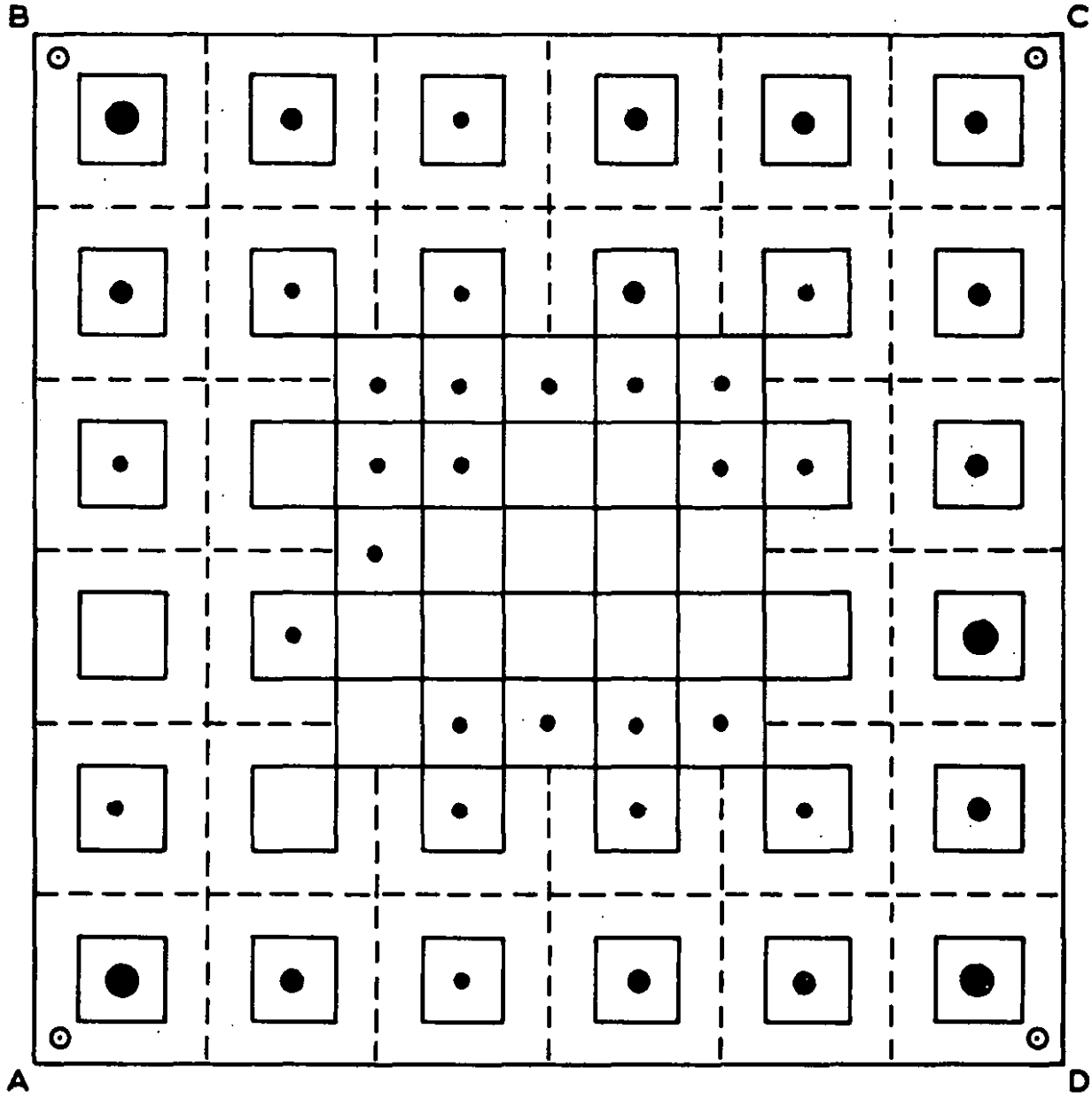


Make P

Type SPRAY, UPRIGHT

Level 12 ft.

Distribution number 1 c

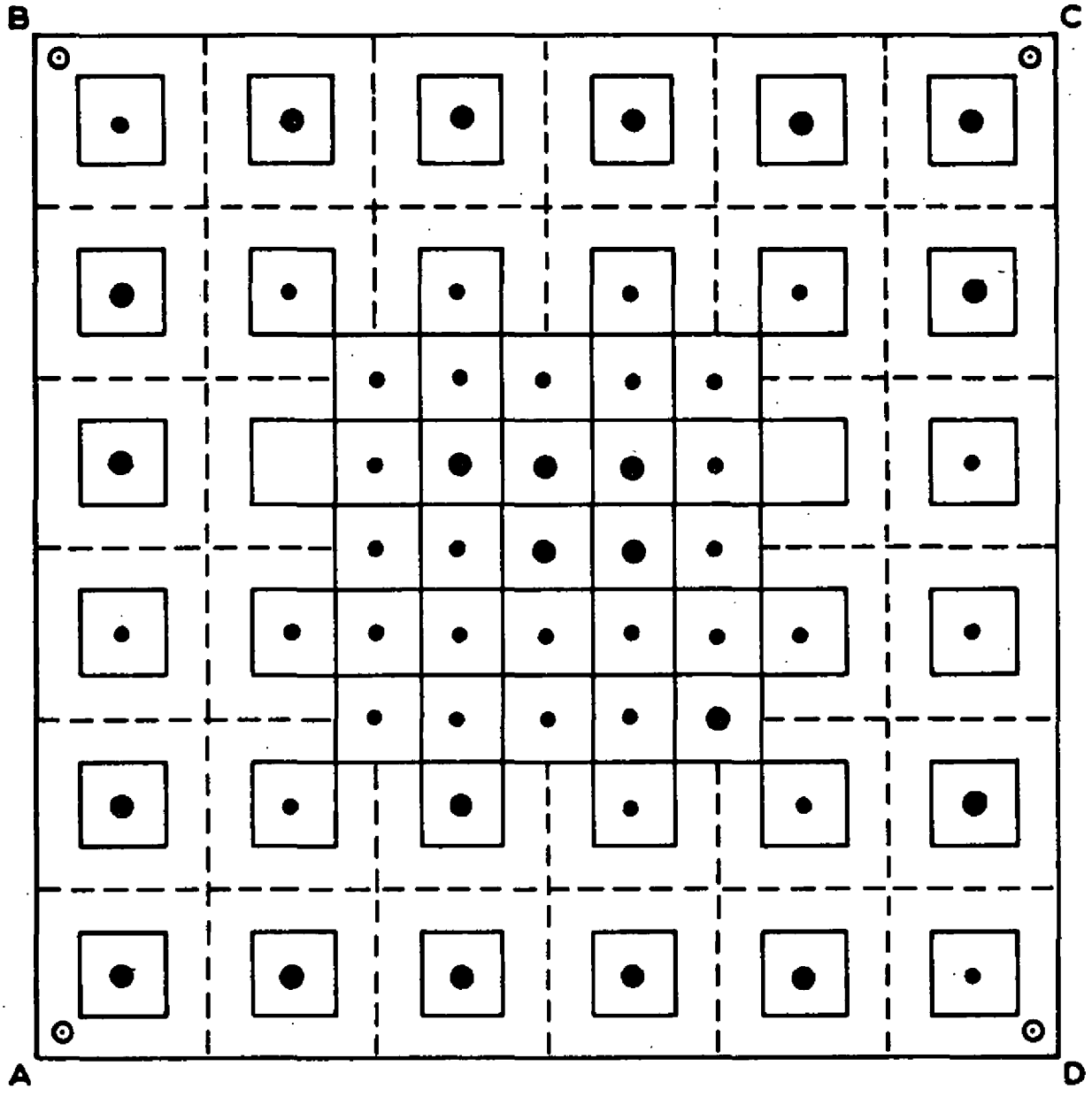


Make 'Q' model 1

Type SPRAY, UPRIGHT

Level 2 ft.

Distribution number 2 a

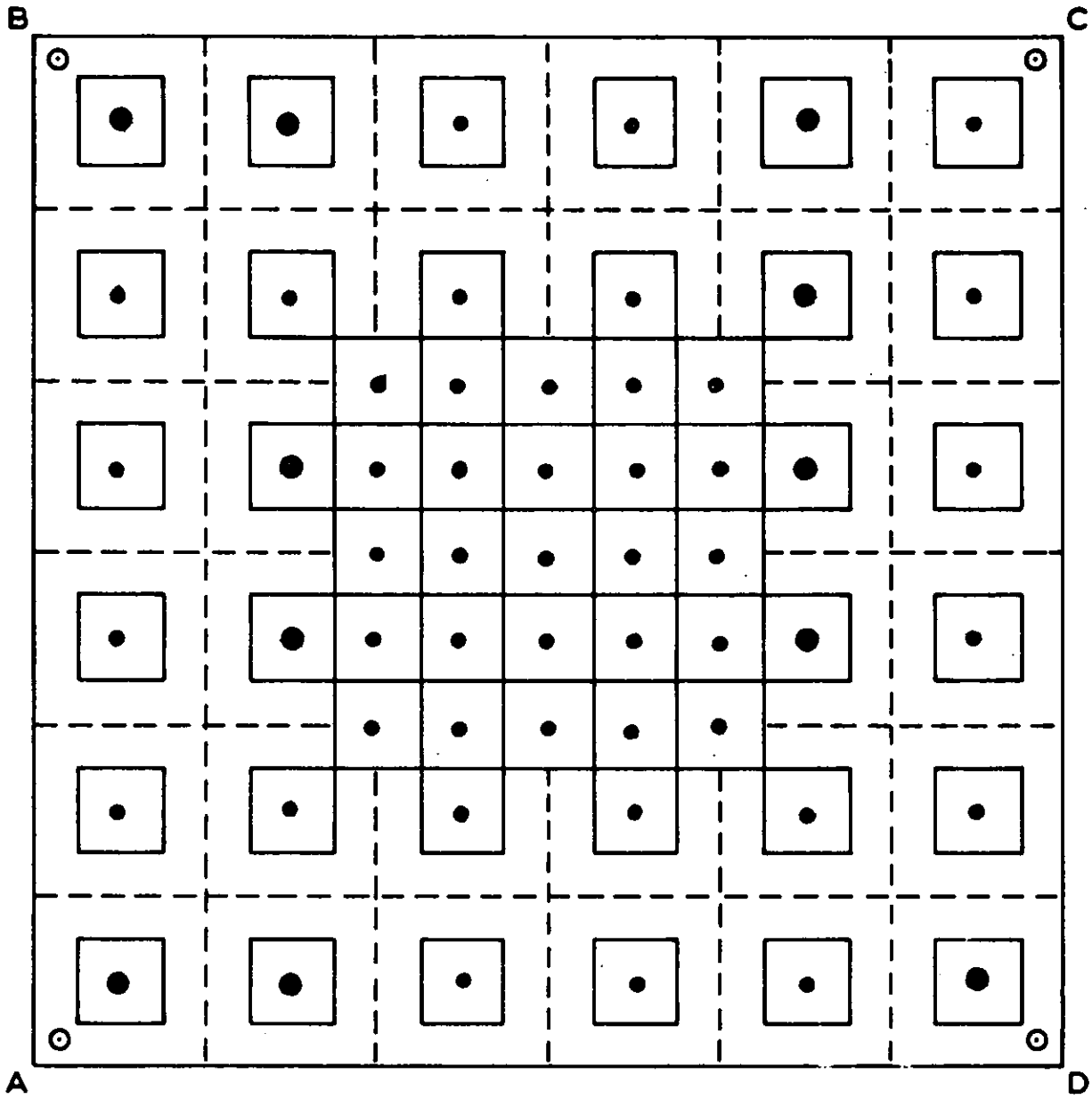


Make 'Q' model 1

Type SPRAY, UPRIGHT

Level 4 ft.

Distribution number 2 b

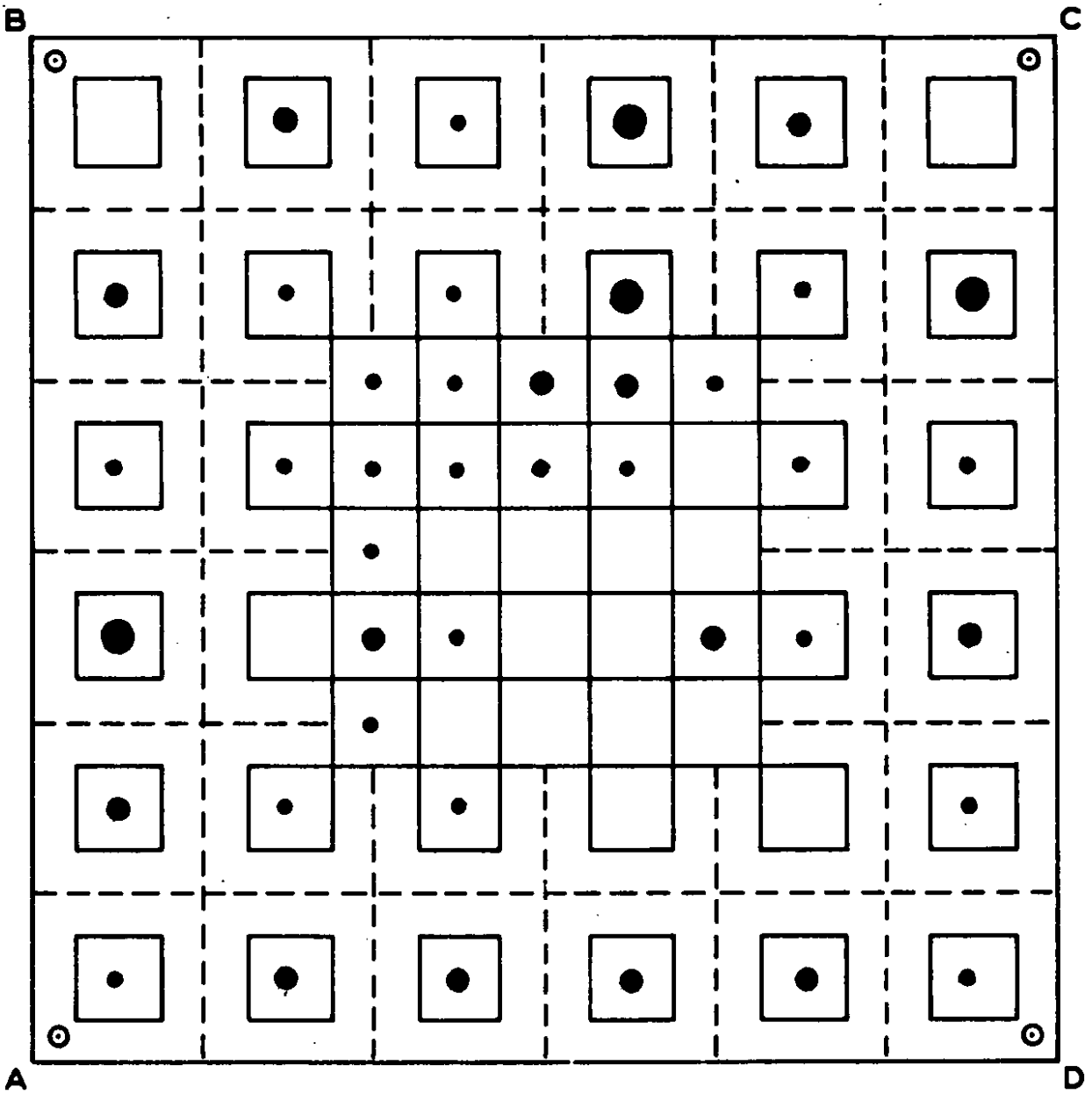


Make 'Q' model 1

Type SPRAY, UPRIGHT

Level 12 ft.

Distribution number 2 c.

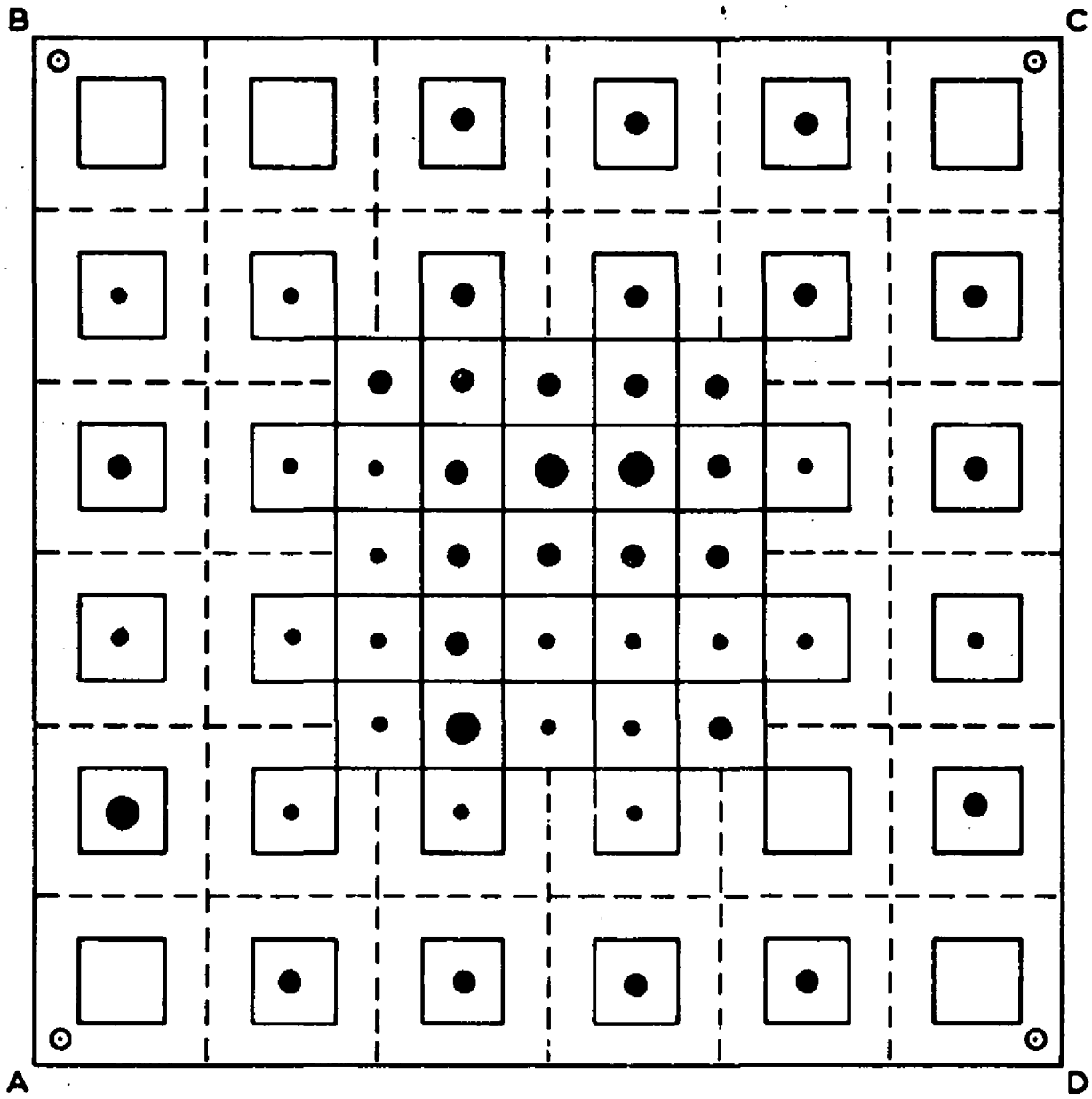


Make 'Q' model 2

Type SPRAY, UPRIGHT

Level 2 ft.

Distribution number 3 a.

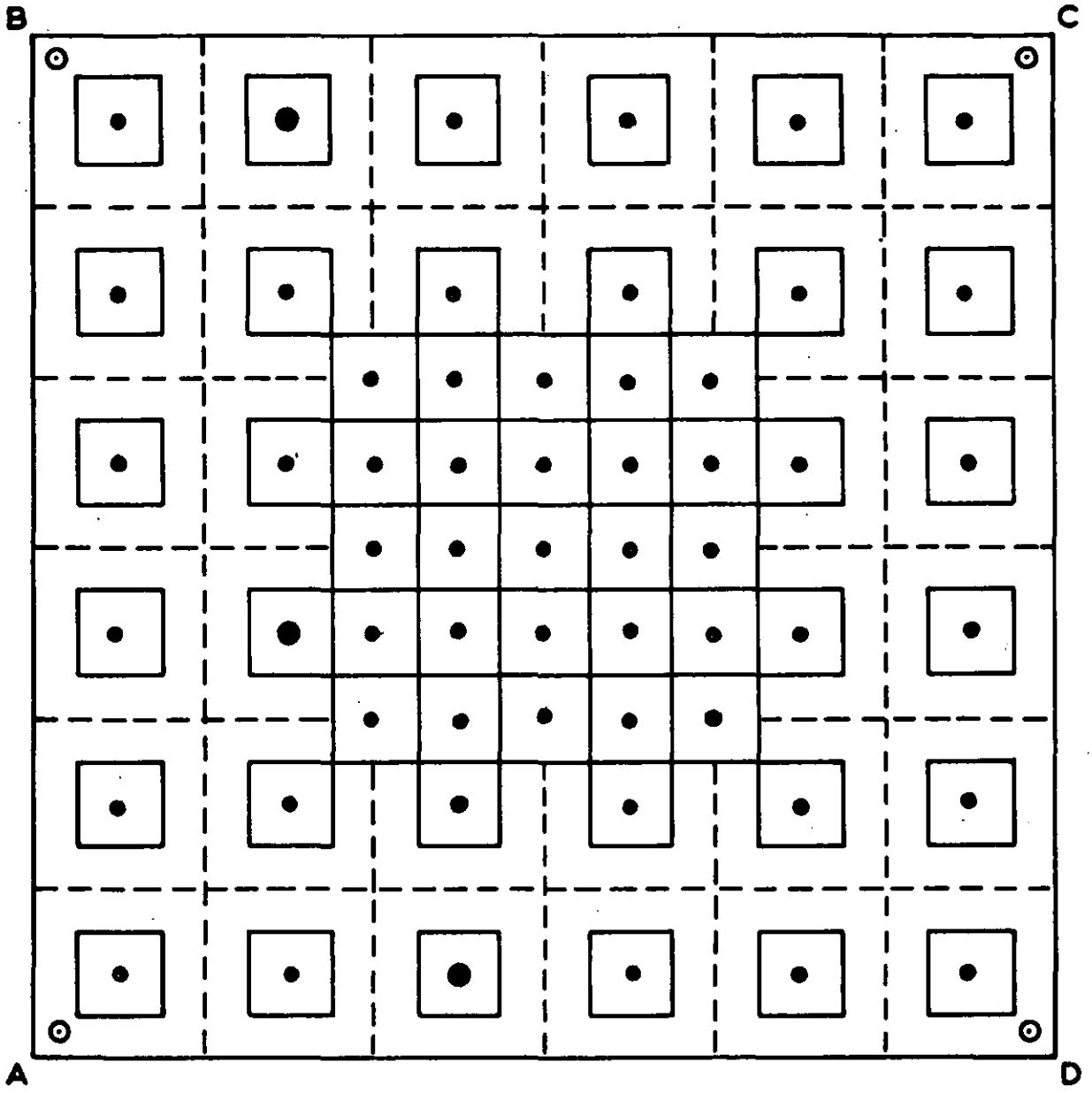


Make 'Q' model 2

Type SPRAY, UPRIGHT

Level 4 ft.

Distribution number 3 b

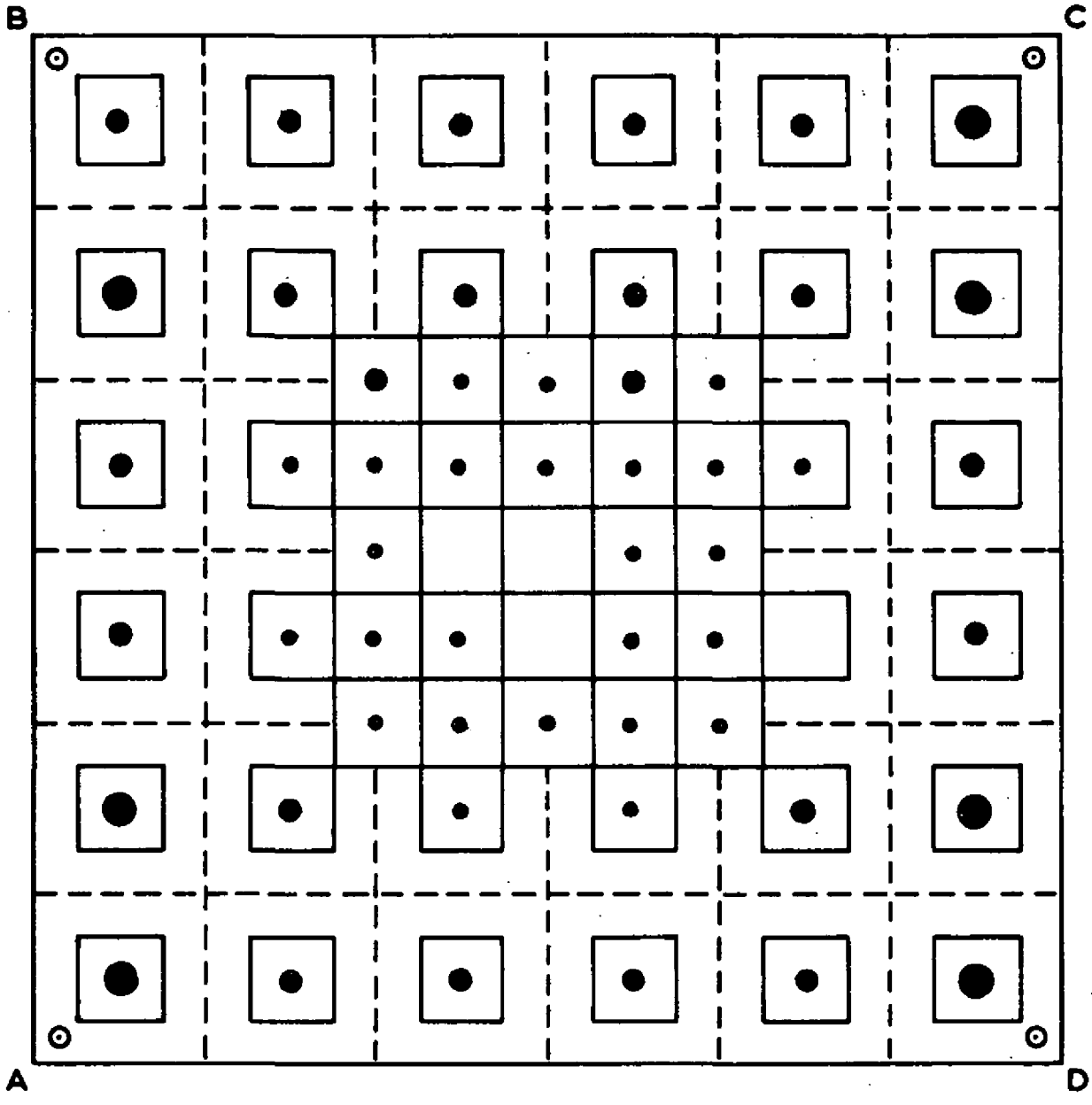


Make 'Q' model 2

Type SPRAY, UPRIGHT

Level 12 ft.

Distribution number 3 c

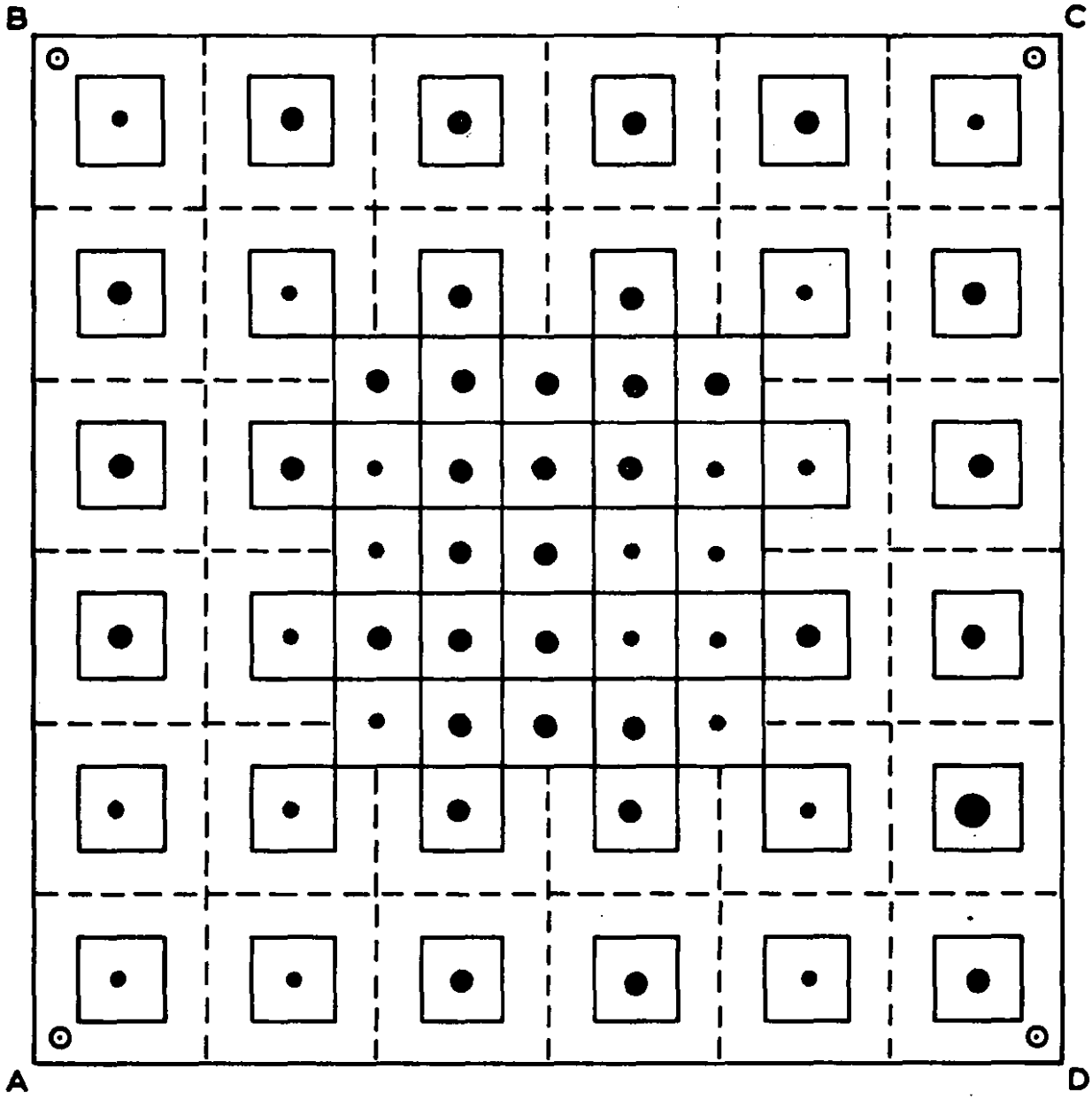


Make R

Type SPRAY, UPRIGHT

Level 2 ft.

Distribution number 4 a

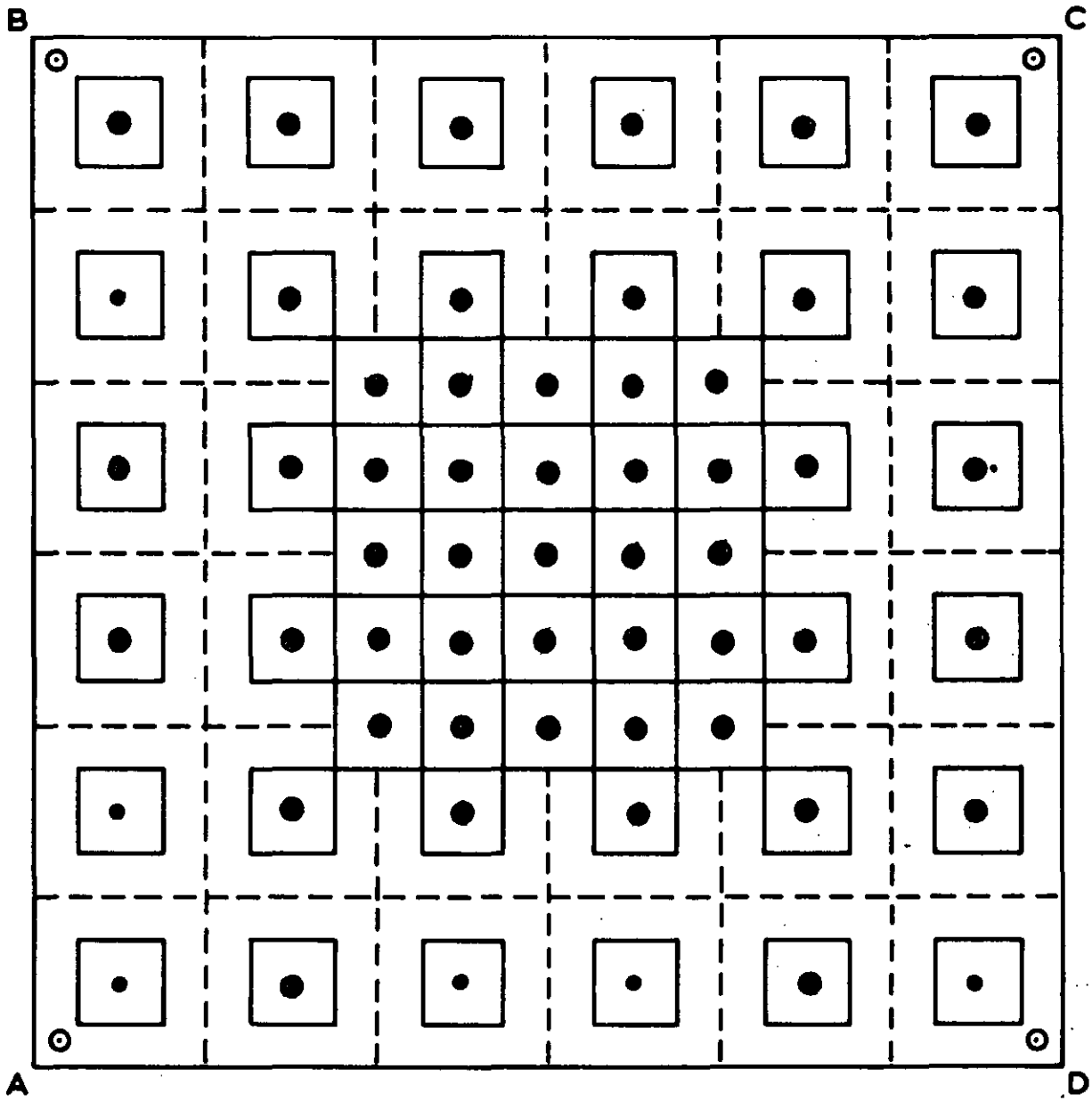


Make R

Type SPRAY, UPRIGHT

Level 4 ft.

Distribution number 4 b

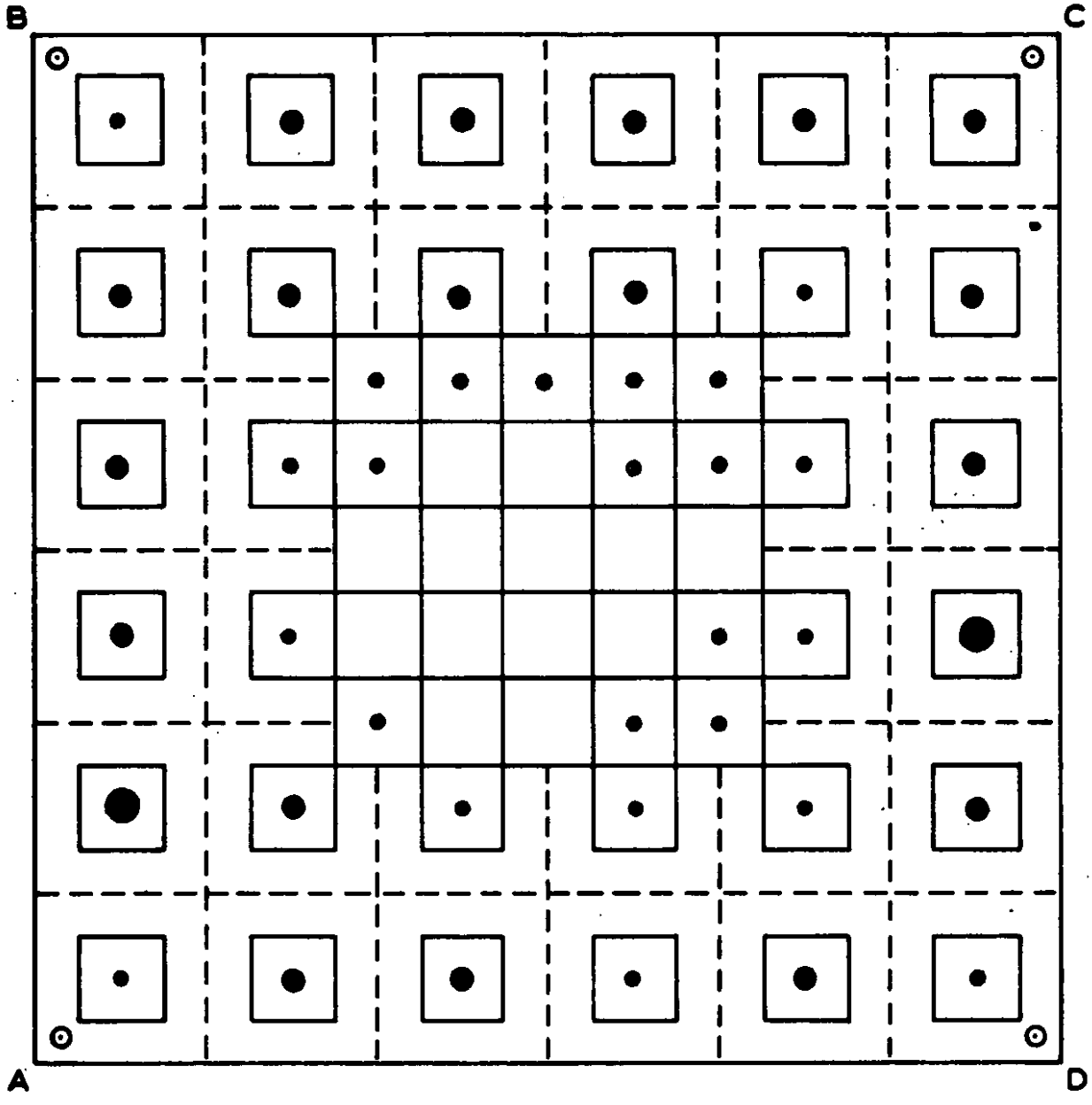


Make R

Type SPRAY, UPRIGHT

Level 12 ft.

Distribution number 4 c.

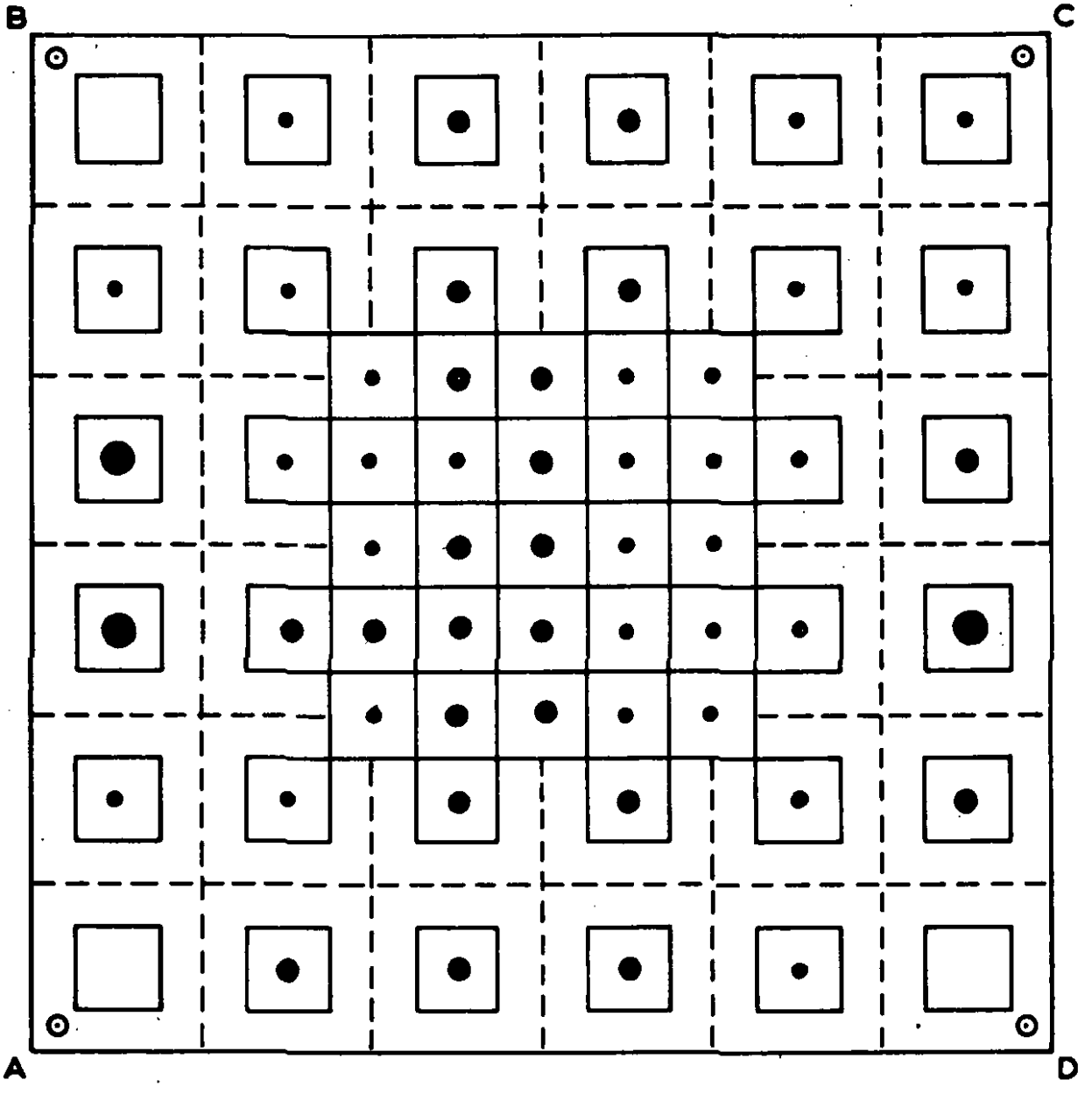


Make 8

Type SPRAY, UPRIGHT

Level 2 ft.

Distribution number 5 a

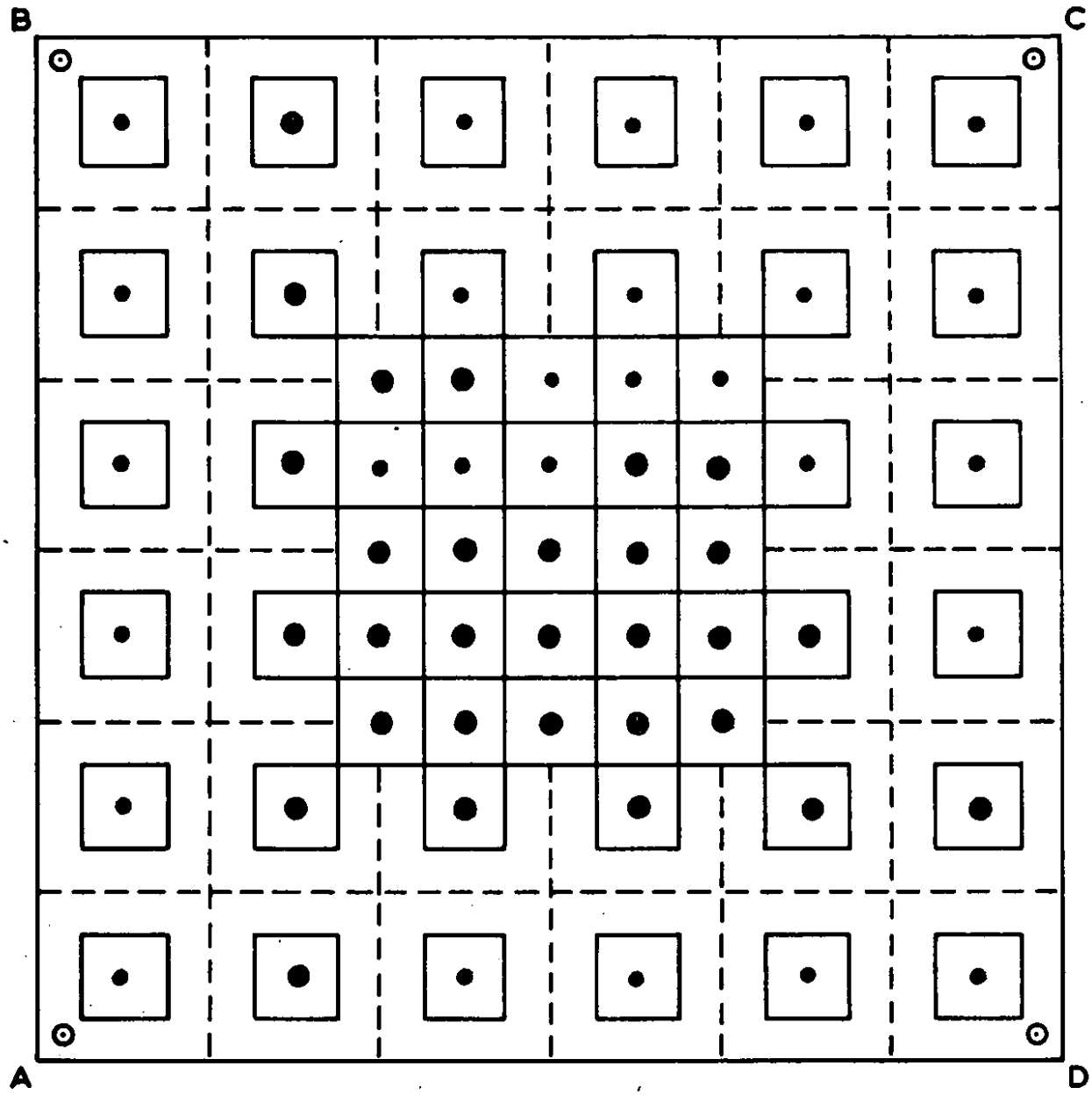


Make S

Type SPRAY, UPRIGHT

Level 4 ft.

Distribution number 5 b.

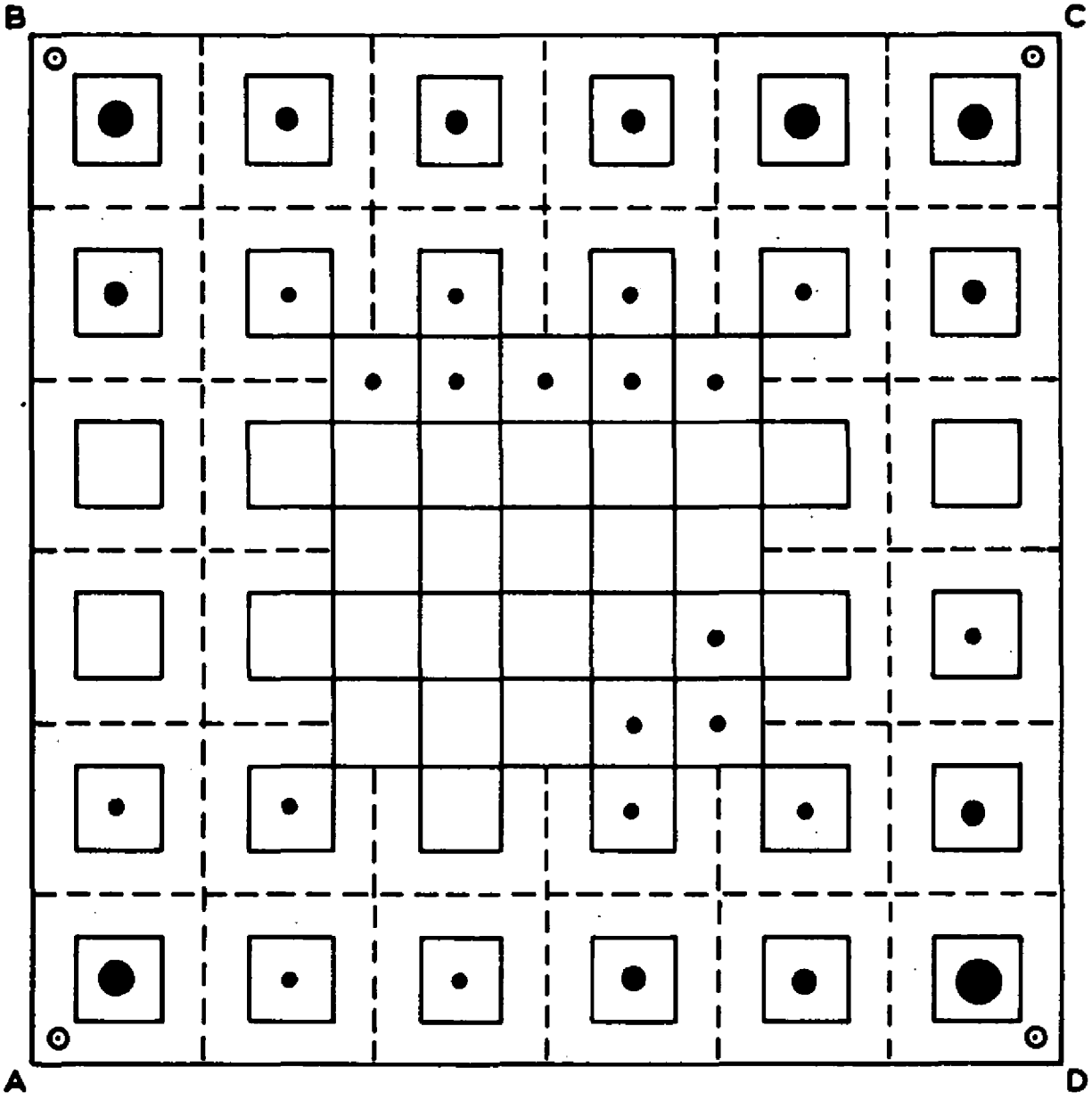


Make S

Type SPRAY, UPRIGHT

Level 12 ft.

Distribution number 5 c

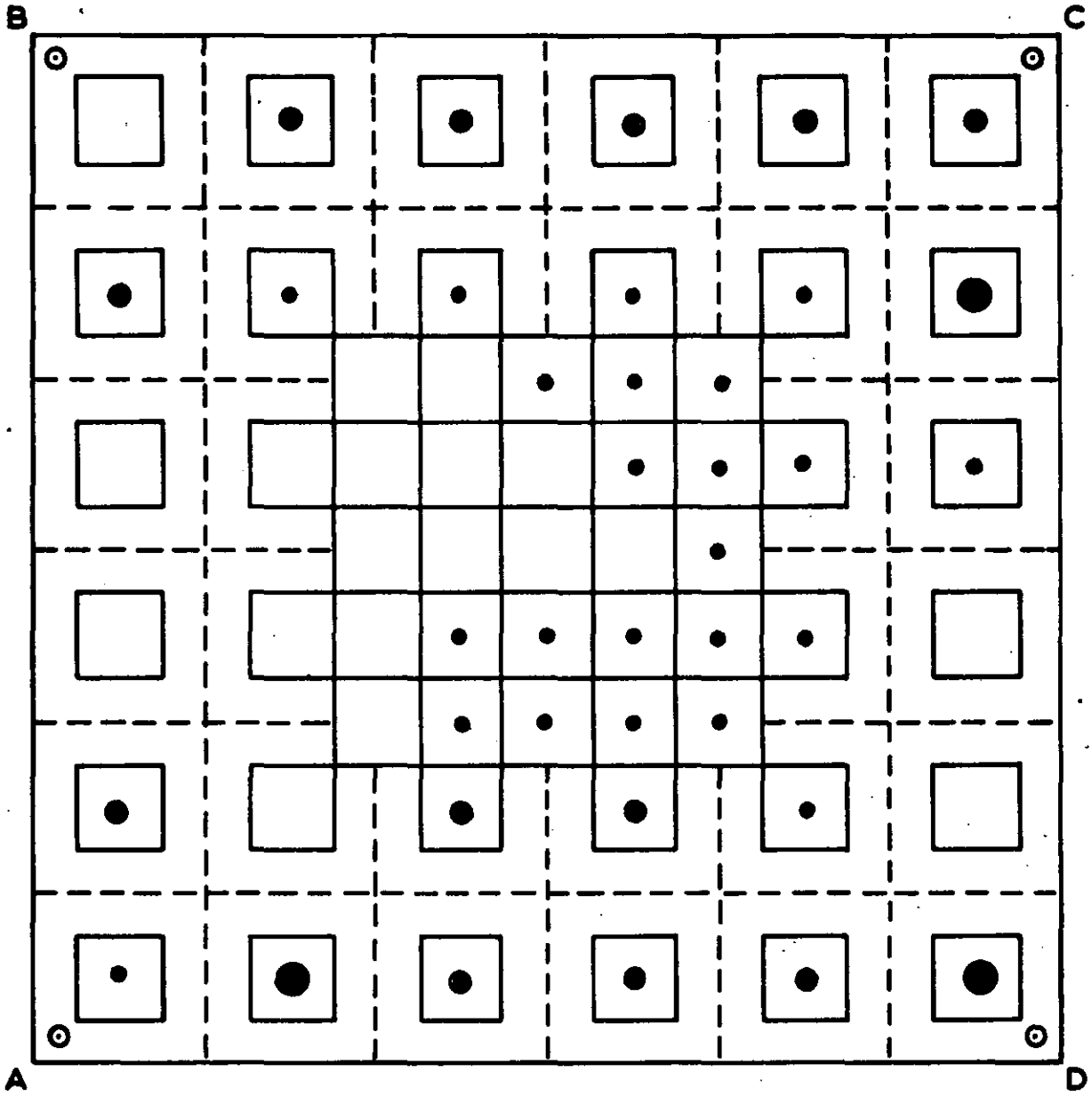


Make T

Type SPRAY, UPRIGHT

Level 2 ft.

Distribution number 6 a.

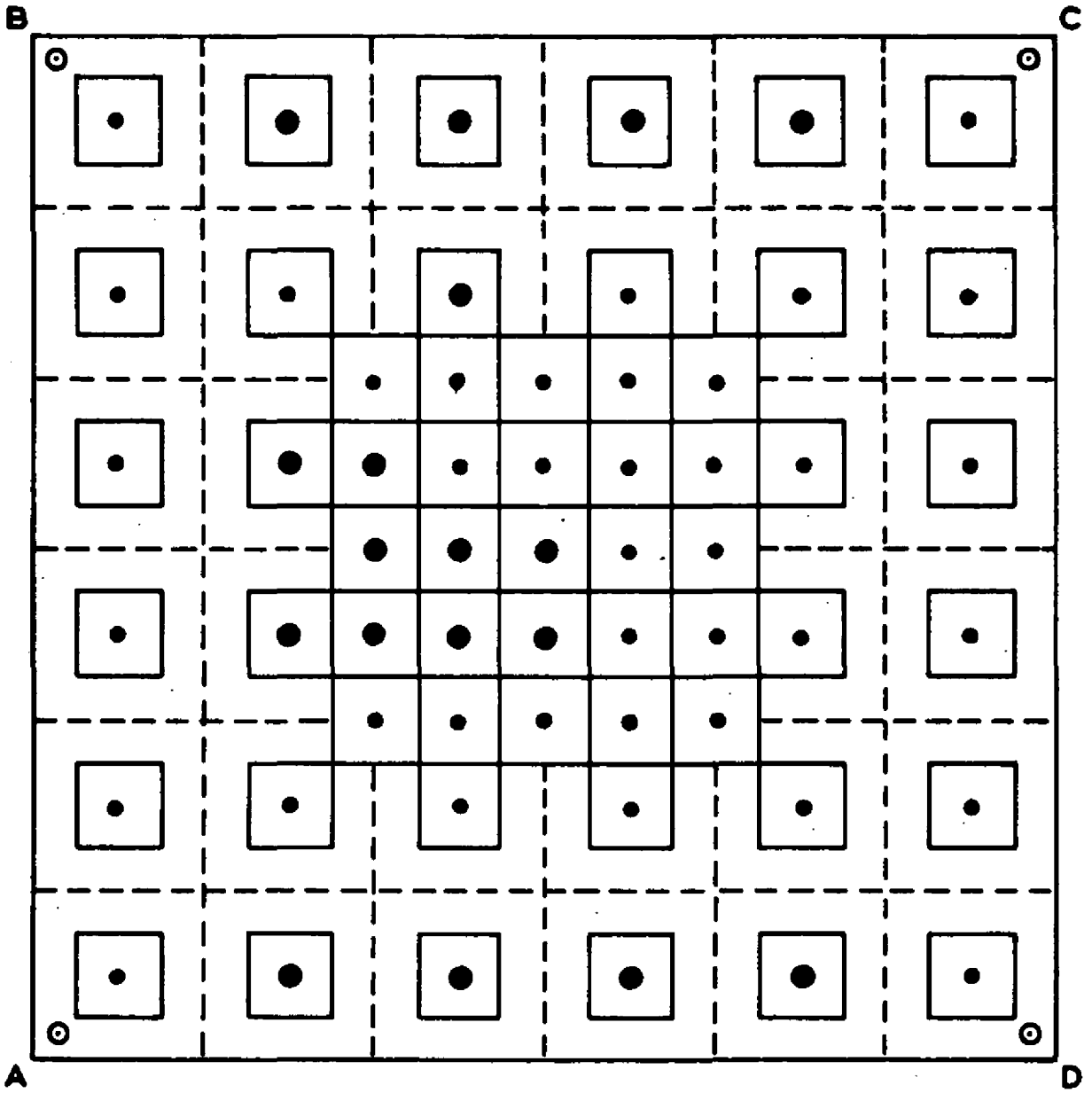


Make T

Type SPRAY, UPRIGHT

Level 4 ft.

Distribution number 6 b.

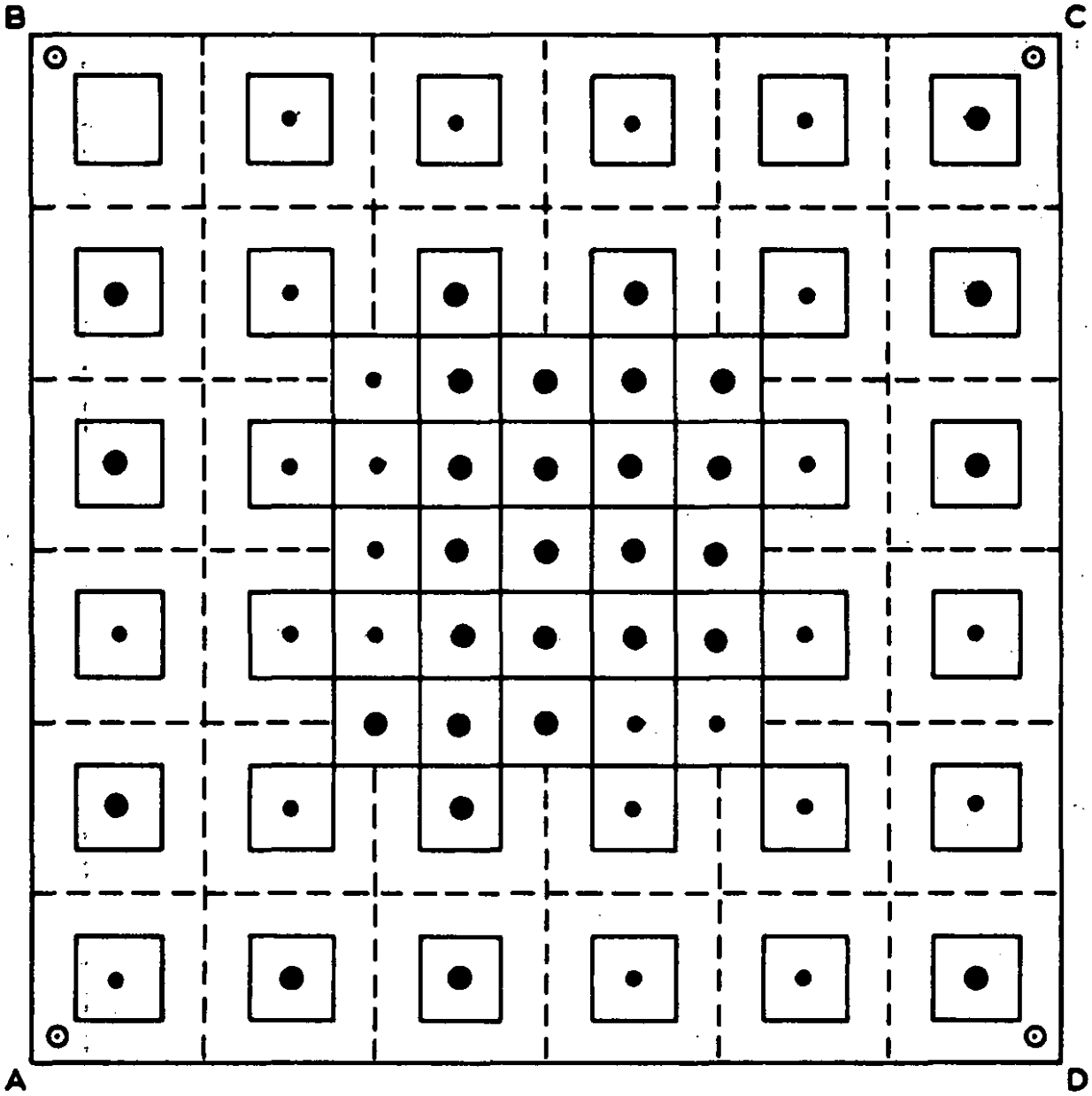


Make T

Type SPRAY, UPRIGHT

Level 12 ft.

Distribution number 6 c

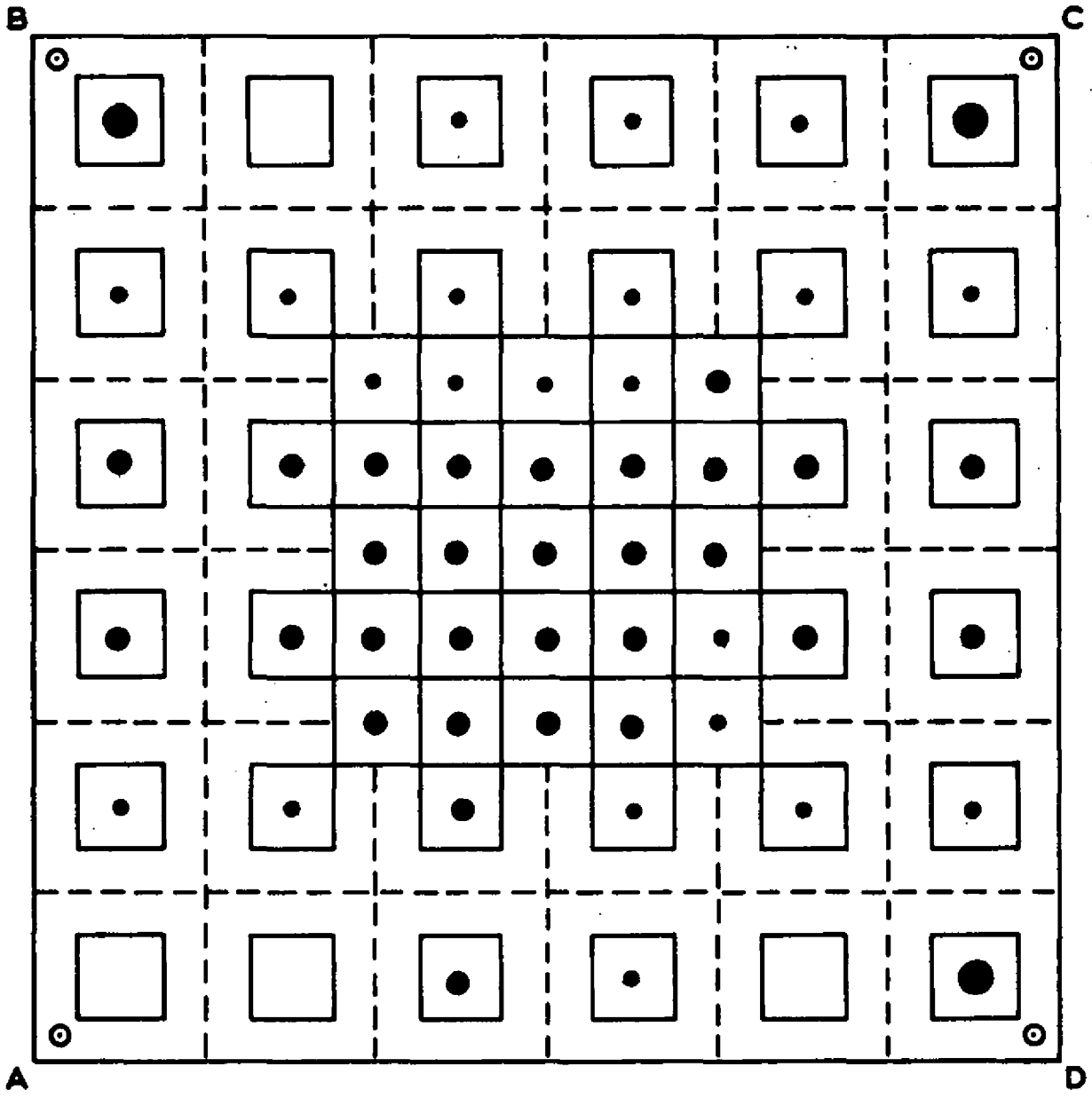


Make P

Type SPRAY, PENDENT

Level 4 ft.

Distribution number 7 a

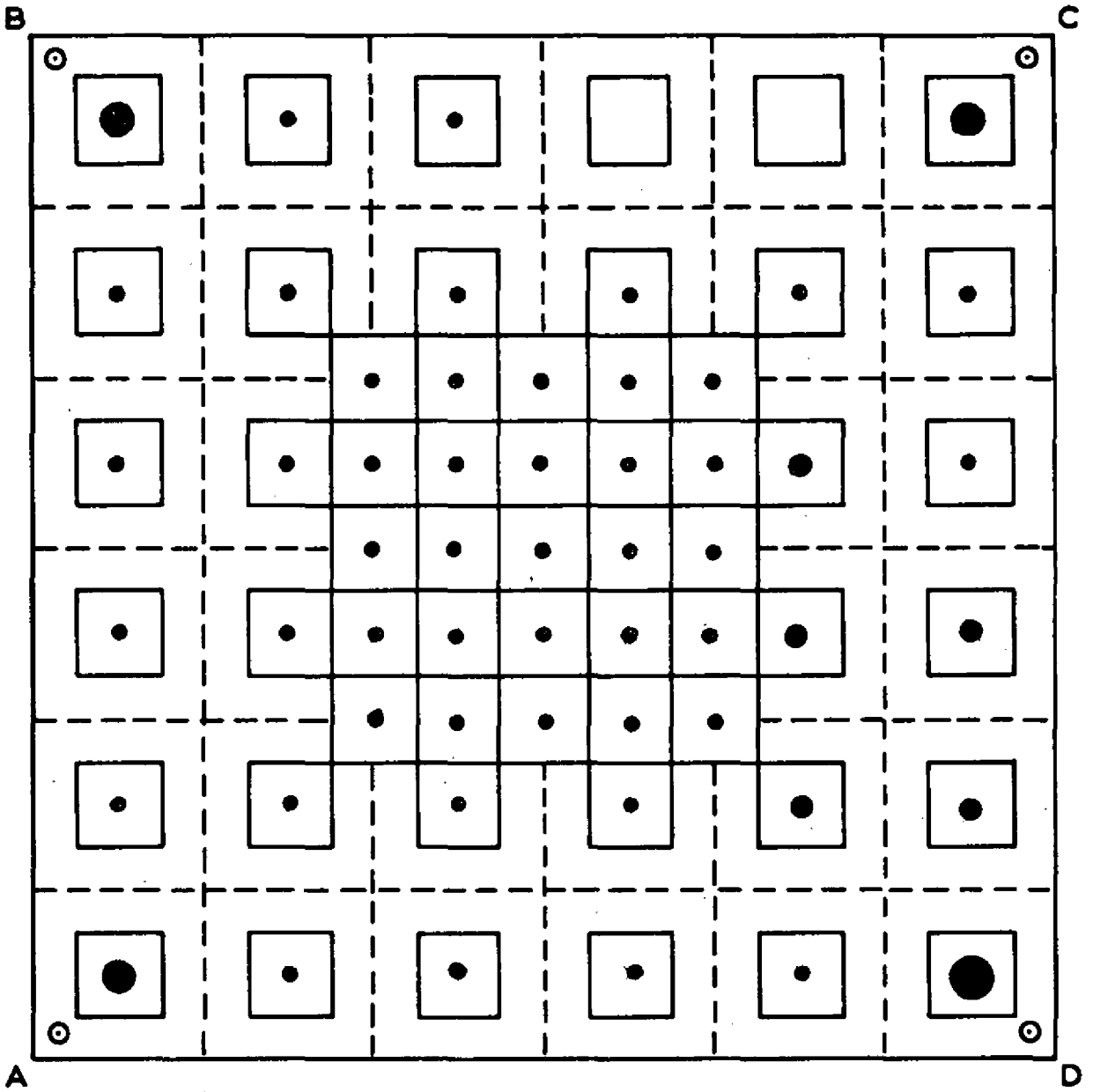


Make P

Type SPRAY, PENDENT

Level 4 ft.

Distribution number 7 b.

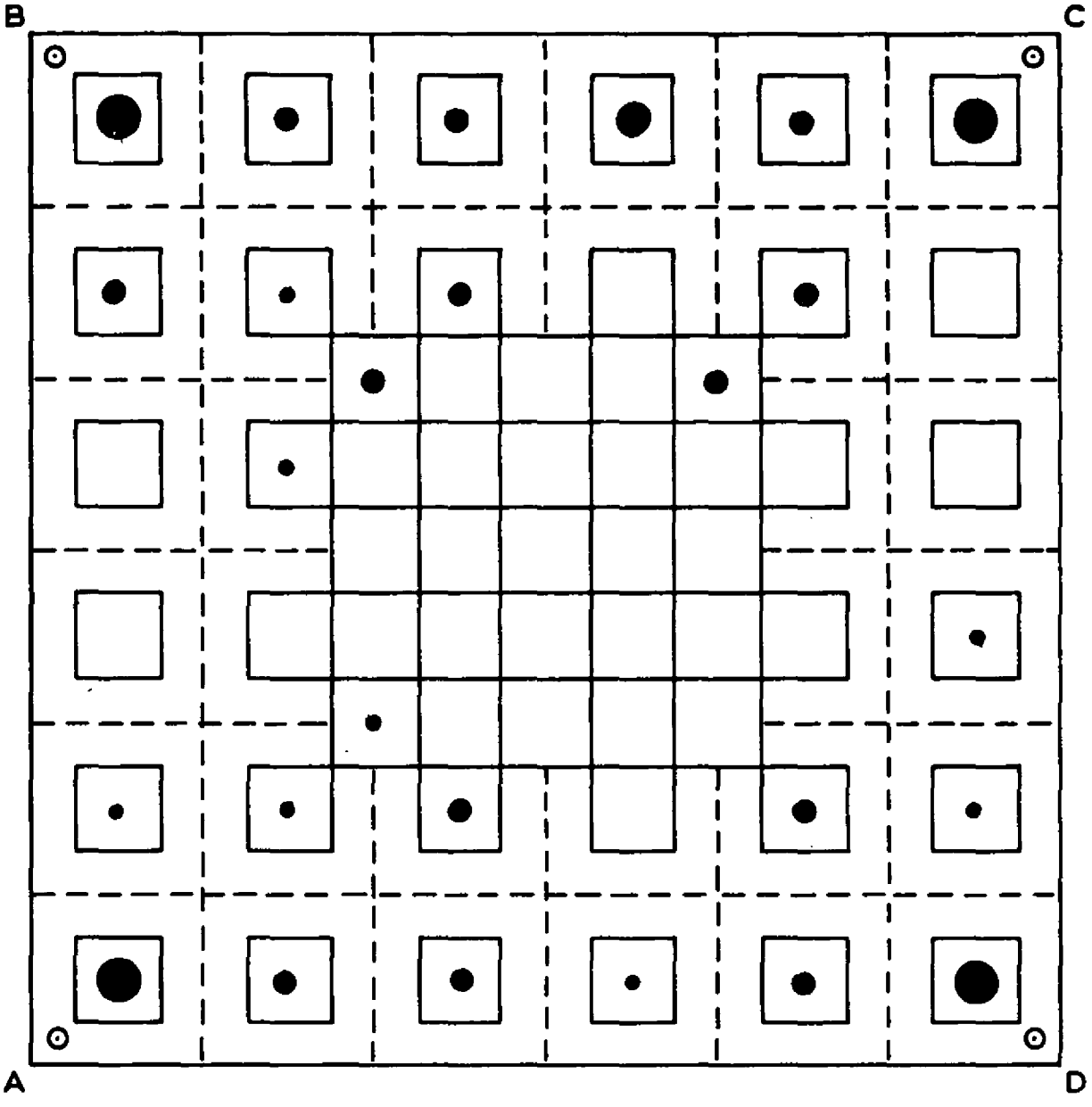


Make P

Type SPRAY, PENDENT

Level 12 ft.

Distribution number 7 c

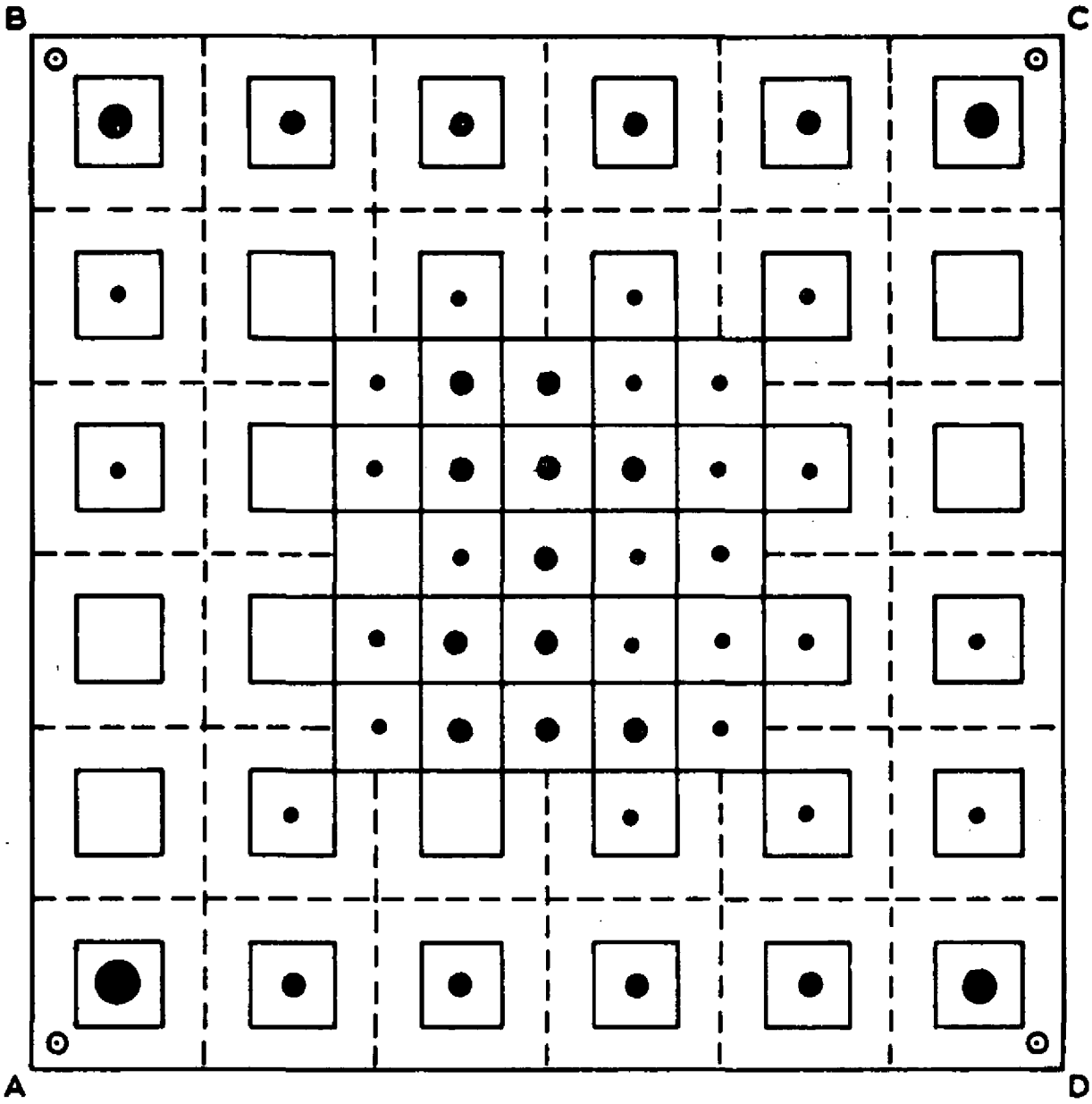


Make 'Q' model 1

Type SPRAY, PENDENT

Level 2 ft.

Distribution number 8 a.

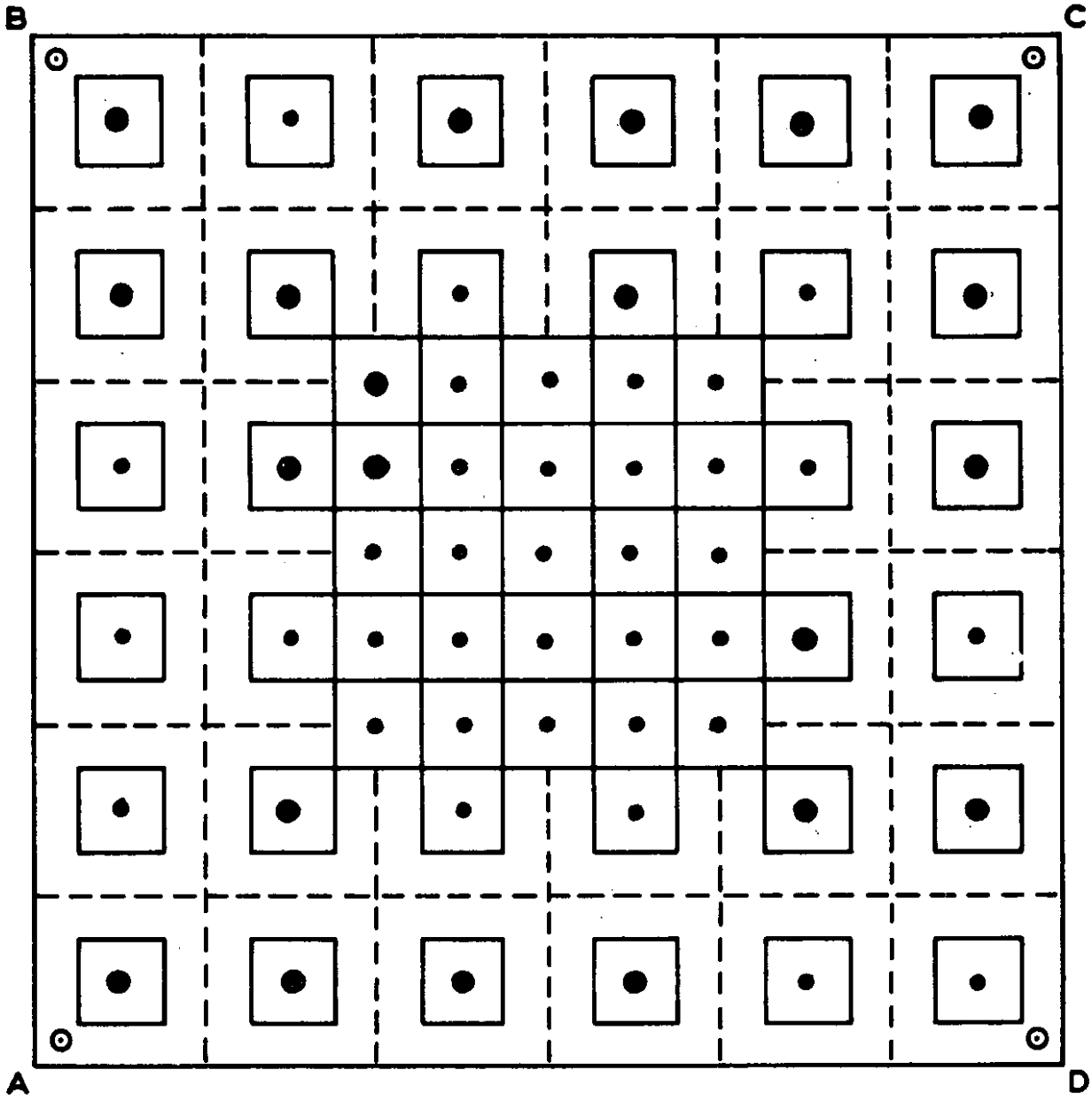


Make 'Q' model 1

Type SPRAY, PENDENT

Level 4 ft.

Distribution number 8 b.

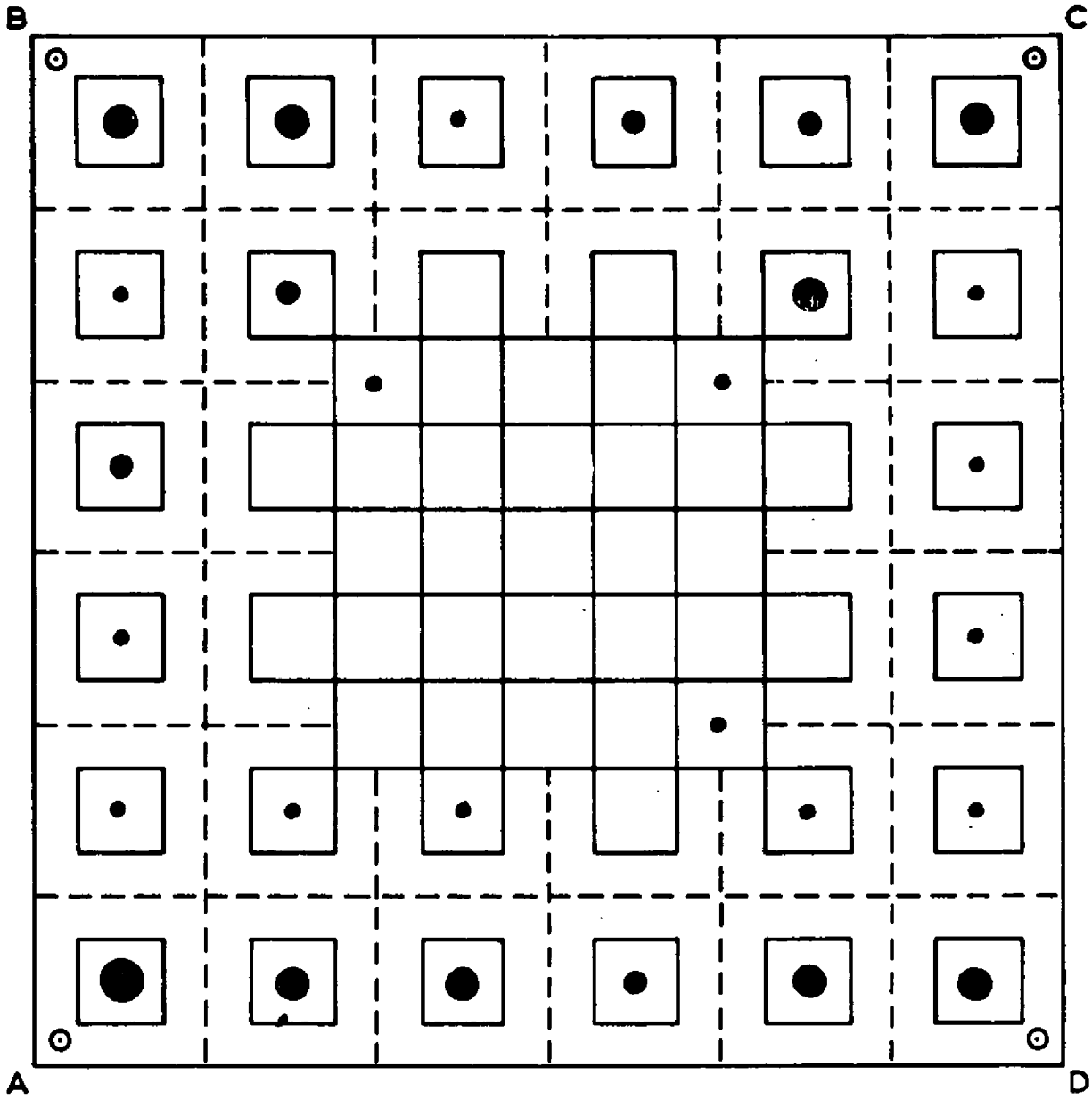


Make 'Q' model 1

Type SPRAY, PENDENT

Level 12 ft.

Distribution number 8 c.

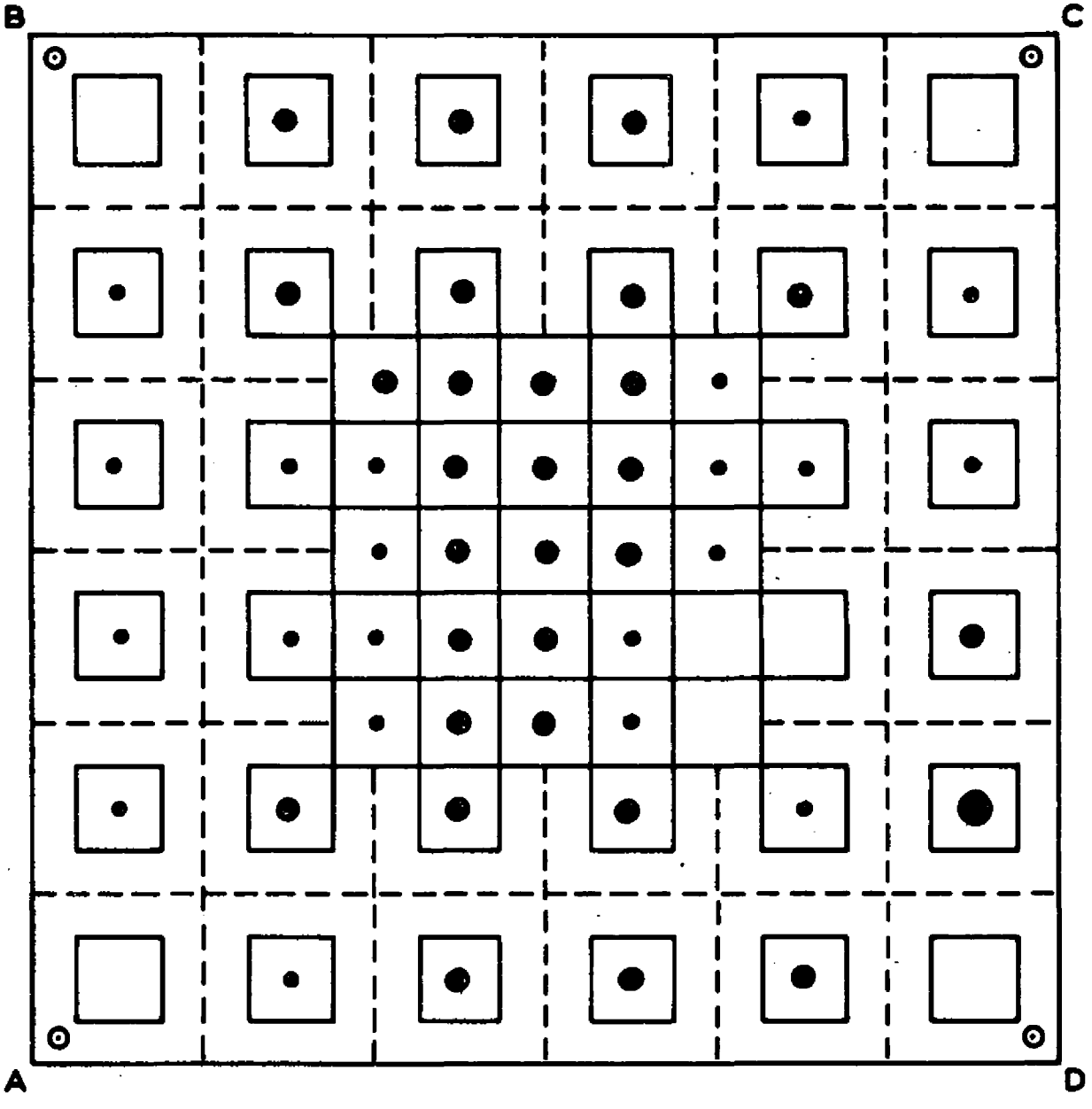


Make 'Q' model 2

Type SPRAY, PENDENT

Level 2 ft.

Distribution number 9 a

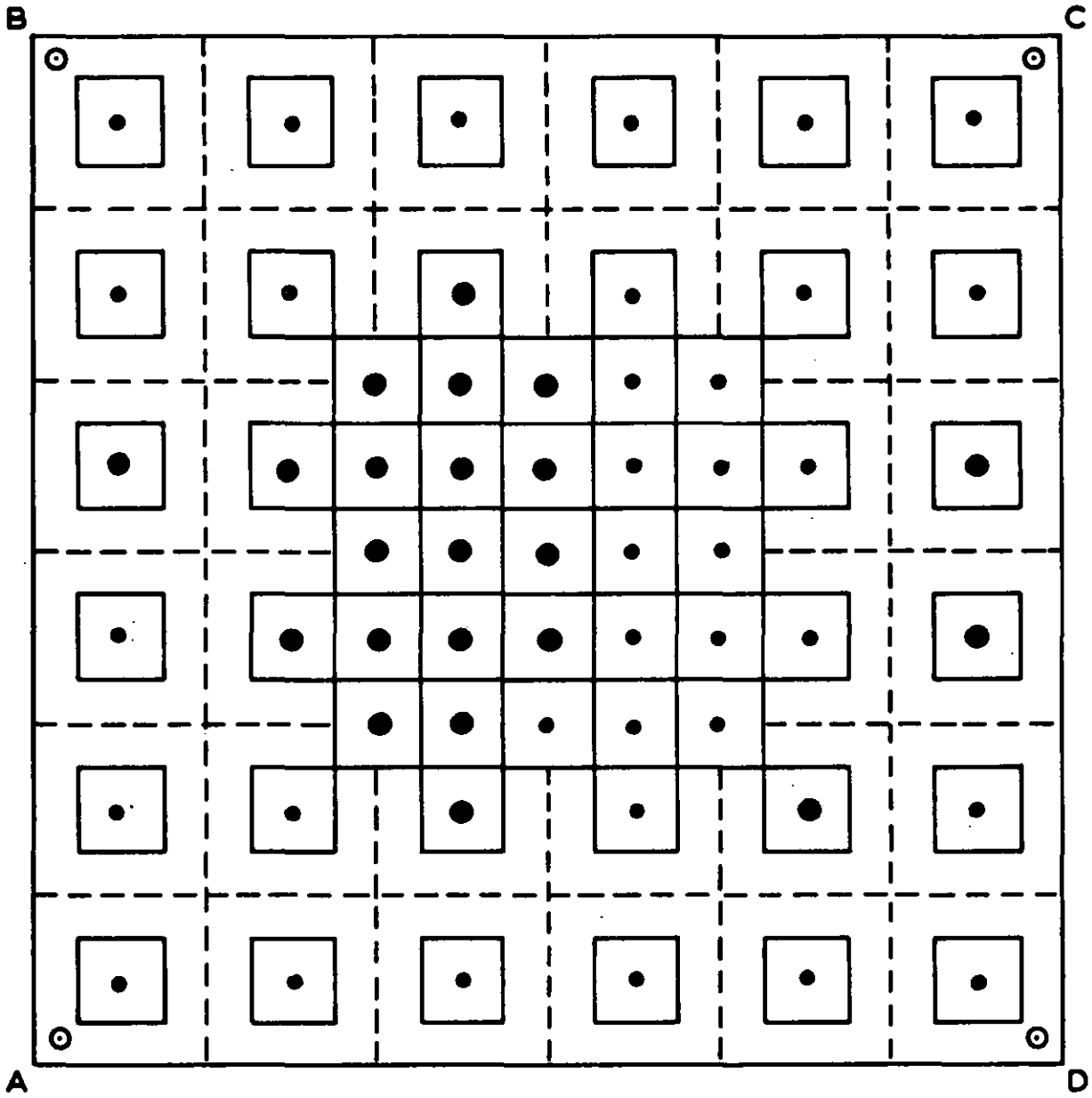


Make 'Q' model 2

Type SPRAY, PENDENT

Level 4 ft.

Distribution number 9 b

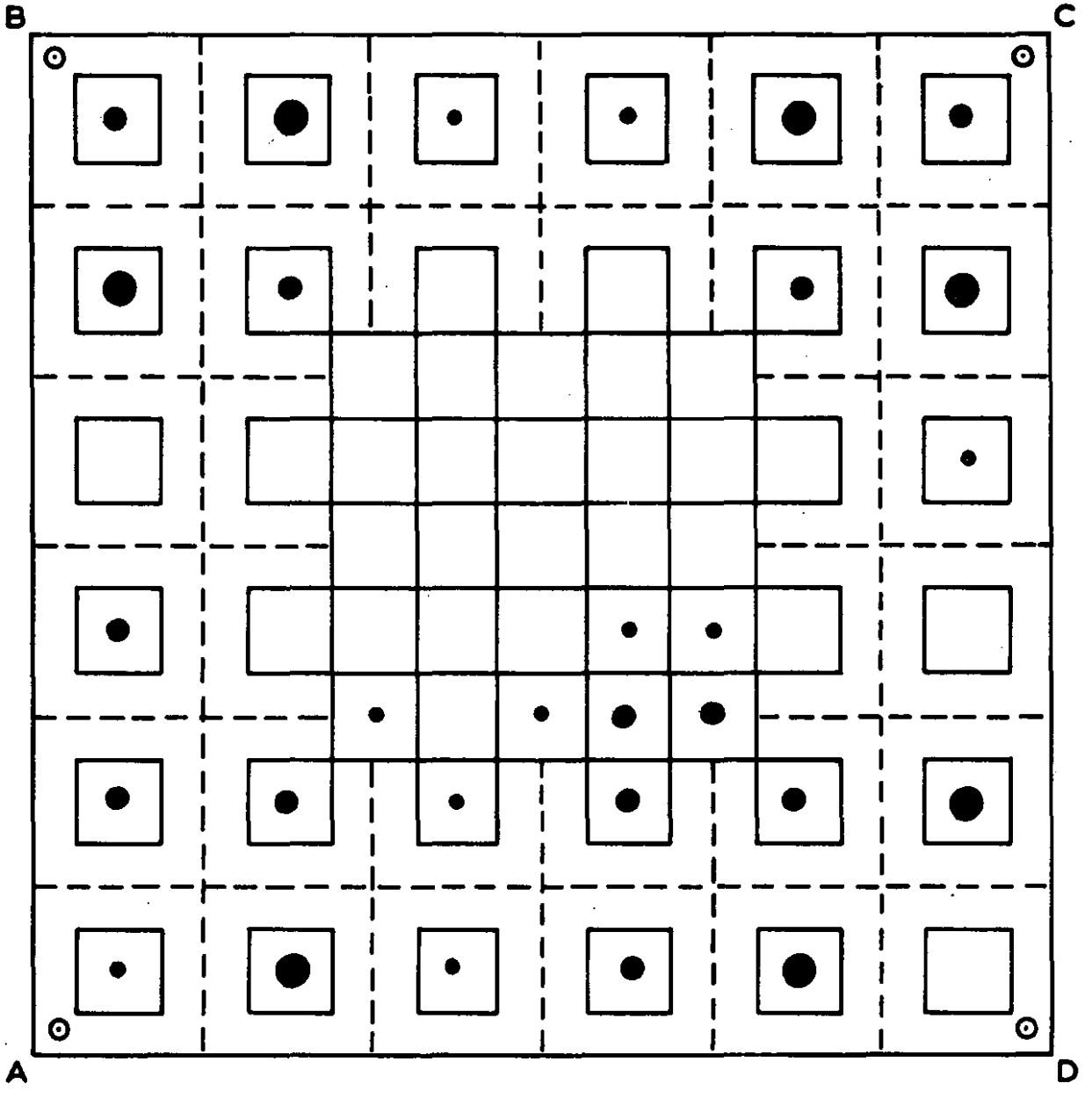


Make 'Q' model 2

Type SPRAY, PENDENT

Level 12 ft.

Distribution number 9 c

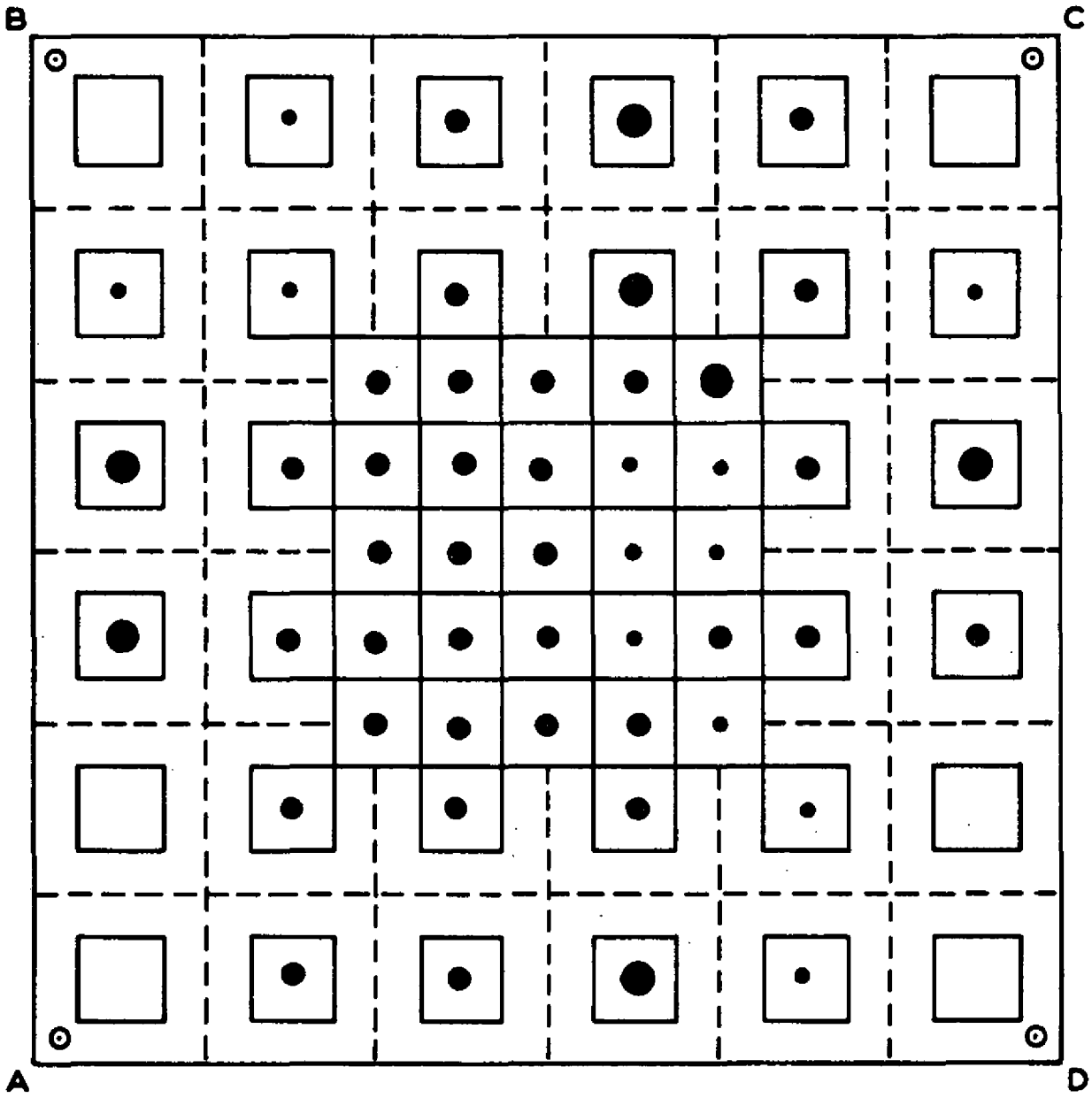


Make R

Type SPRAY, PENDENT

Level 2 ft.

Distribution number 10 a.

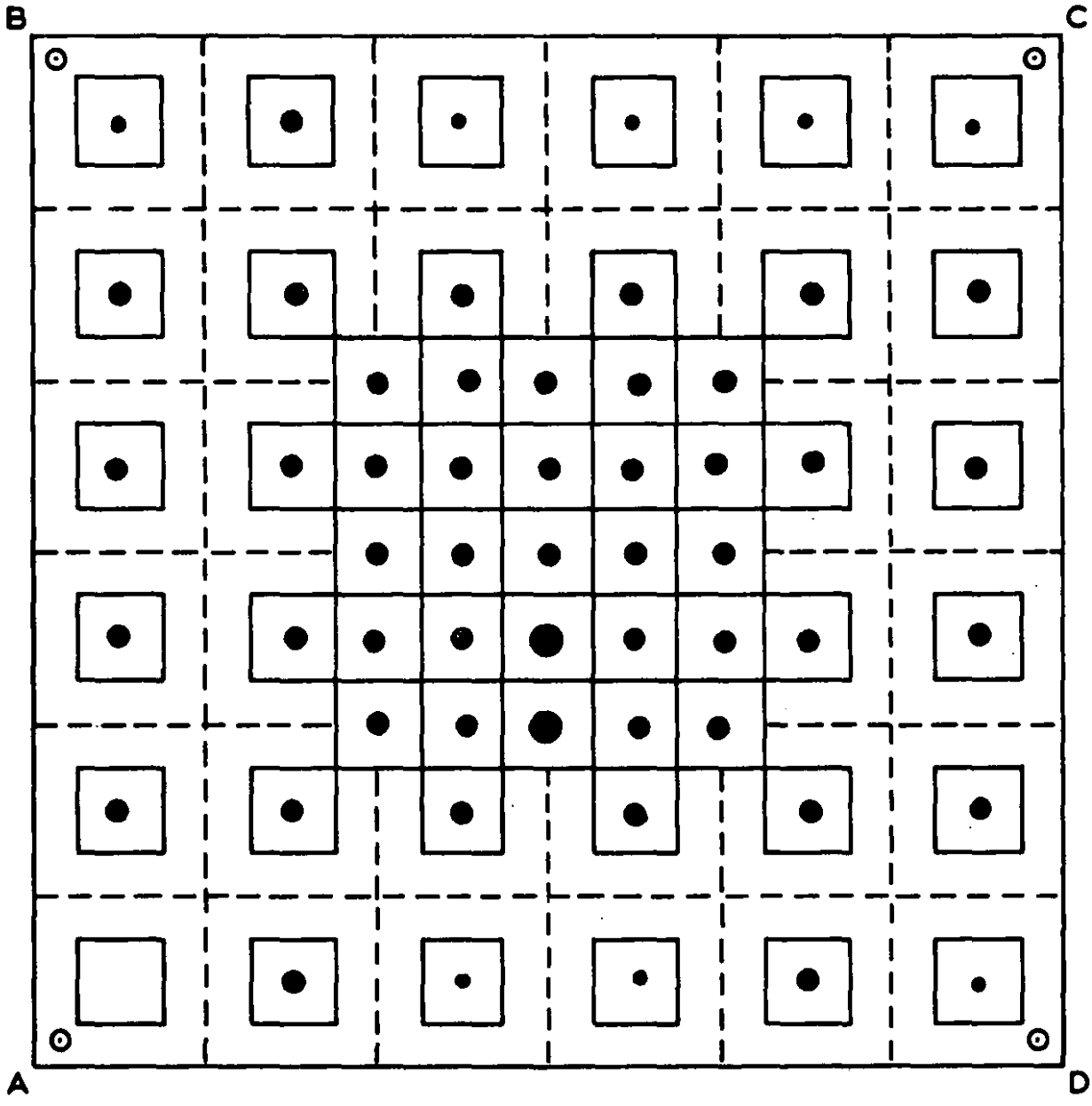


Make . R

Type SPRAY, PENDENT

Level 4 ft.

Distribution number 10 b.

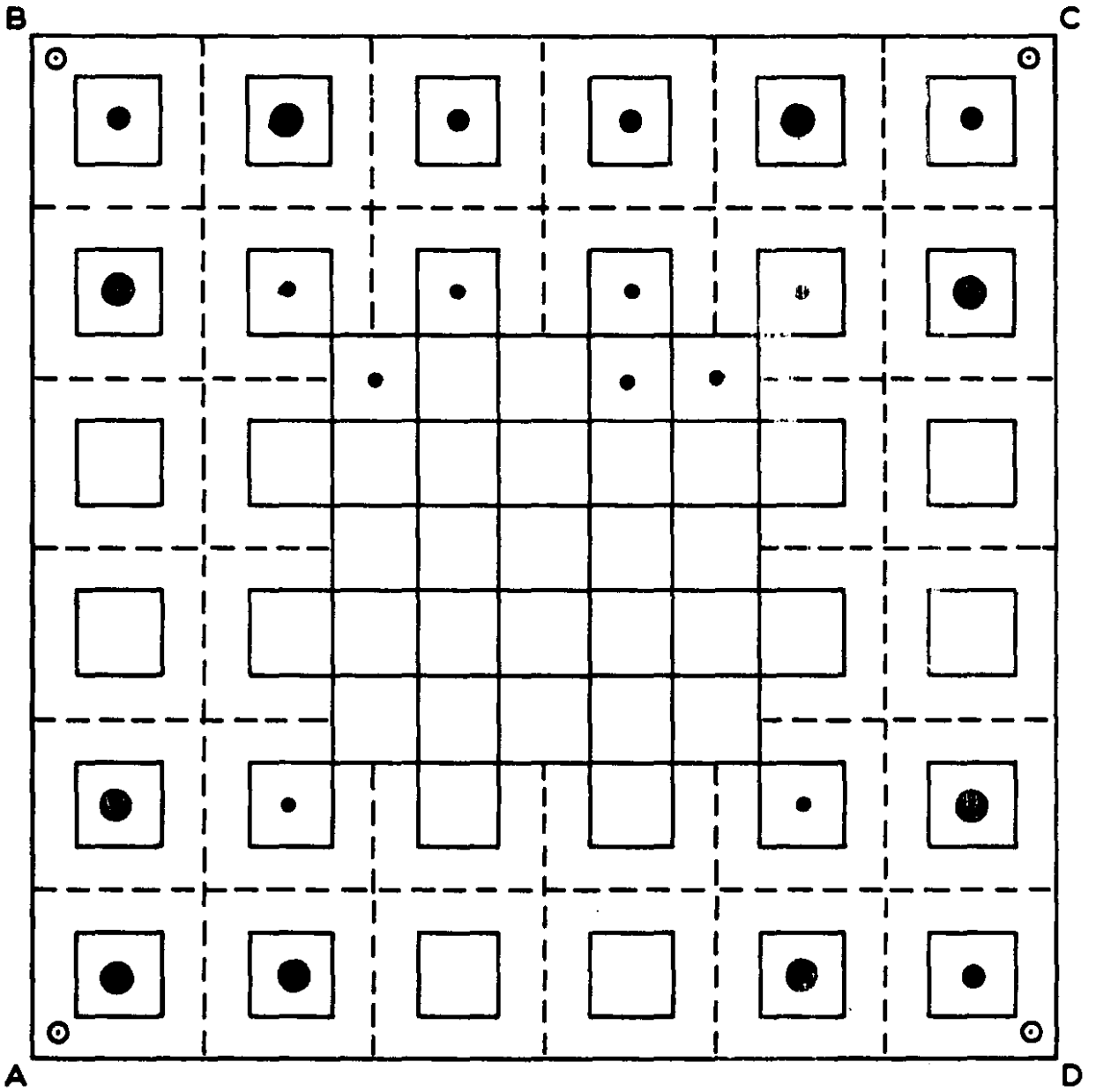


Make R

Type SPRAY, PENDENT

Level 12 ft.

Distribution number 10c.

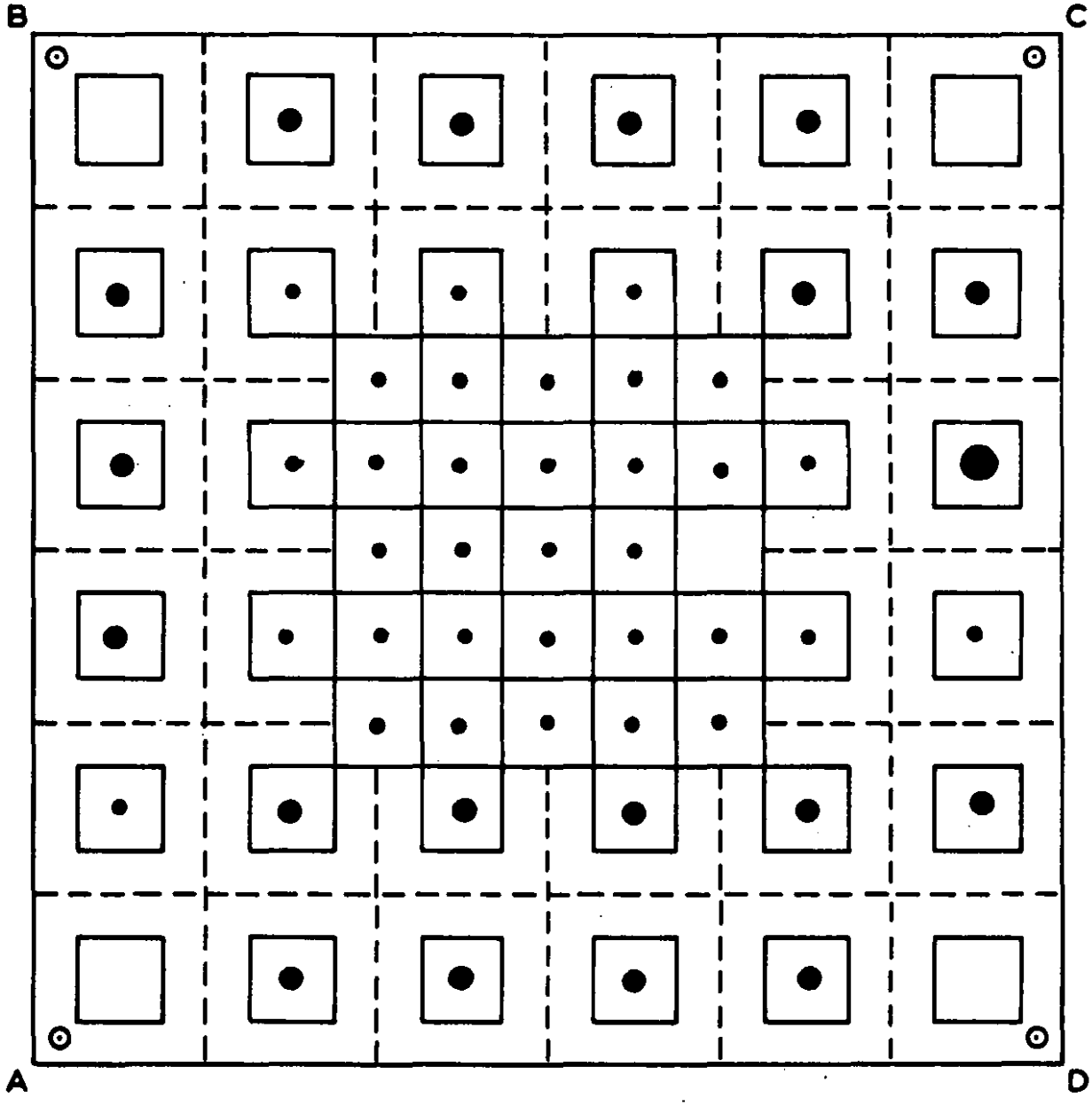


Make S

Type SPRAY, PENDENT

Level 2 ft.

Distribution number 11a.

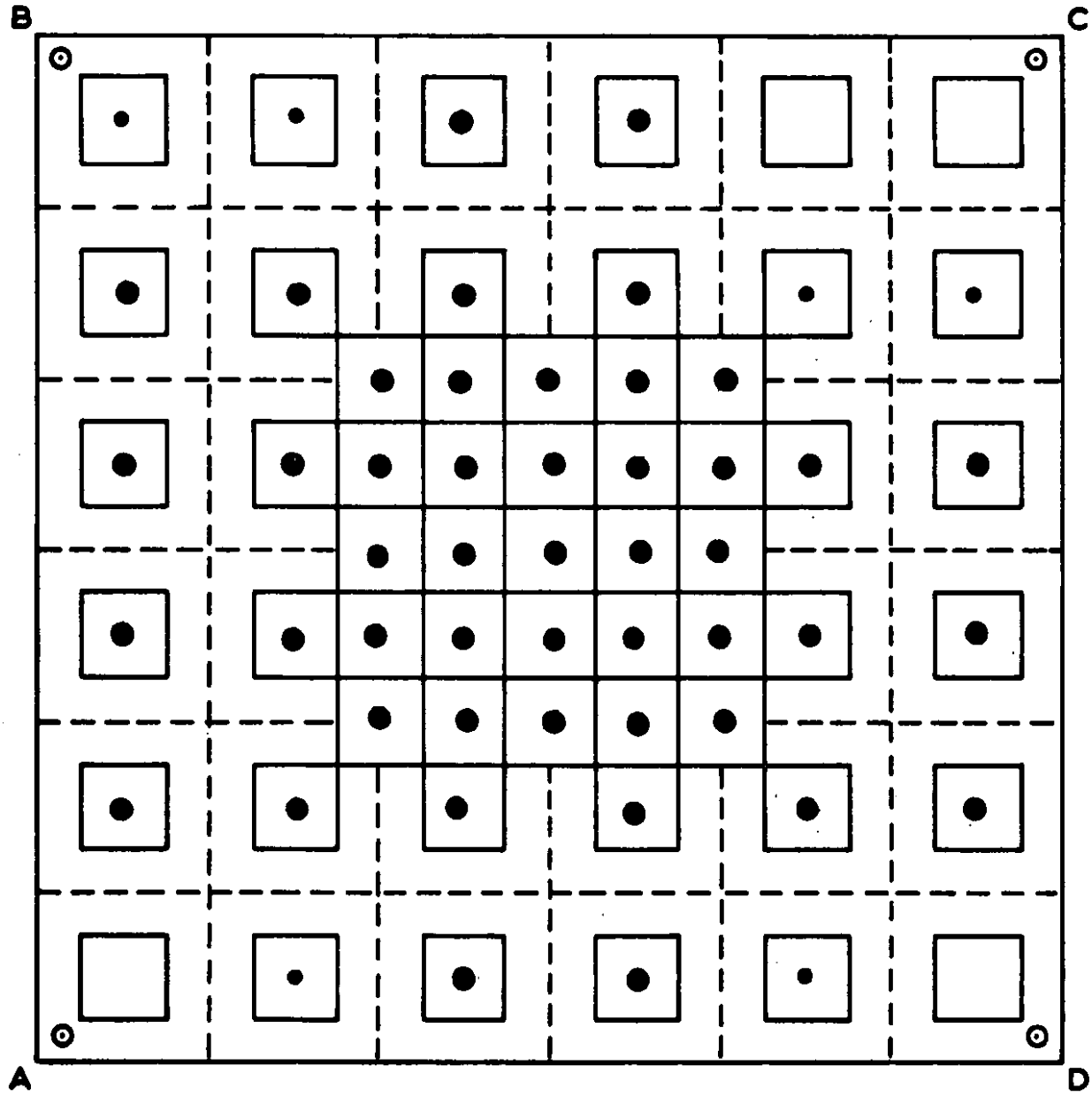


Make S

Type SPRAY, PENDENT

Level 4 ft.

Distribution number 11b.

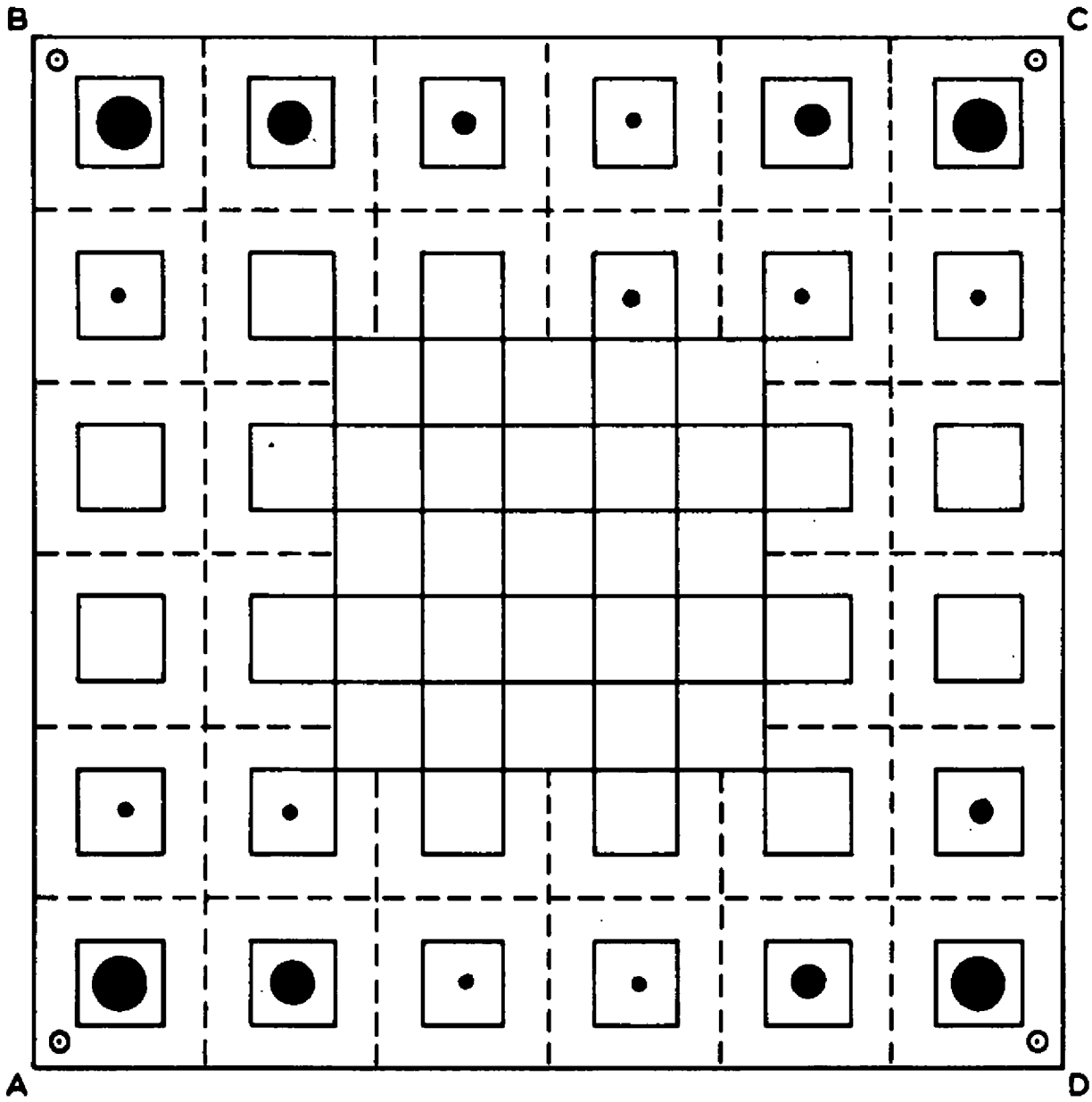


Make S

Type SPRAY, PENDENT

Level 12 ft.

Distribution number 11c.

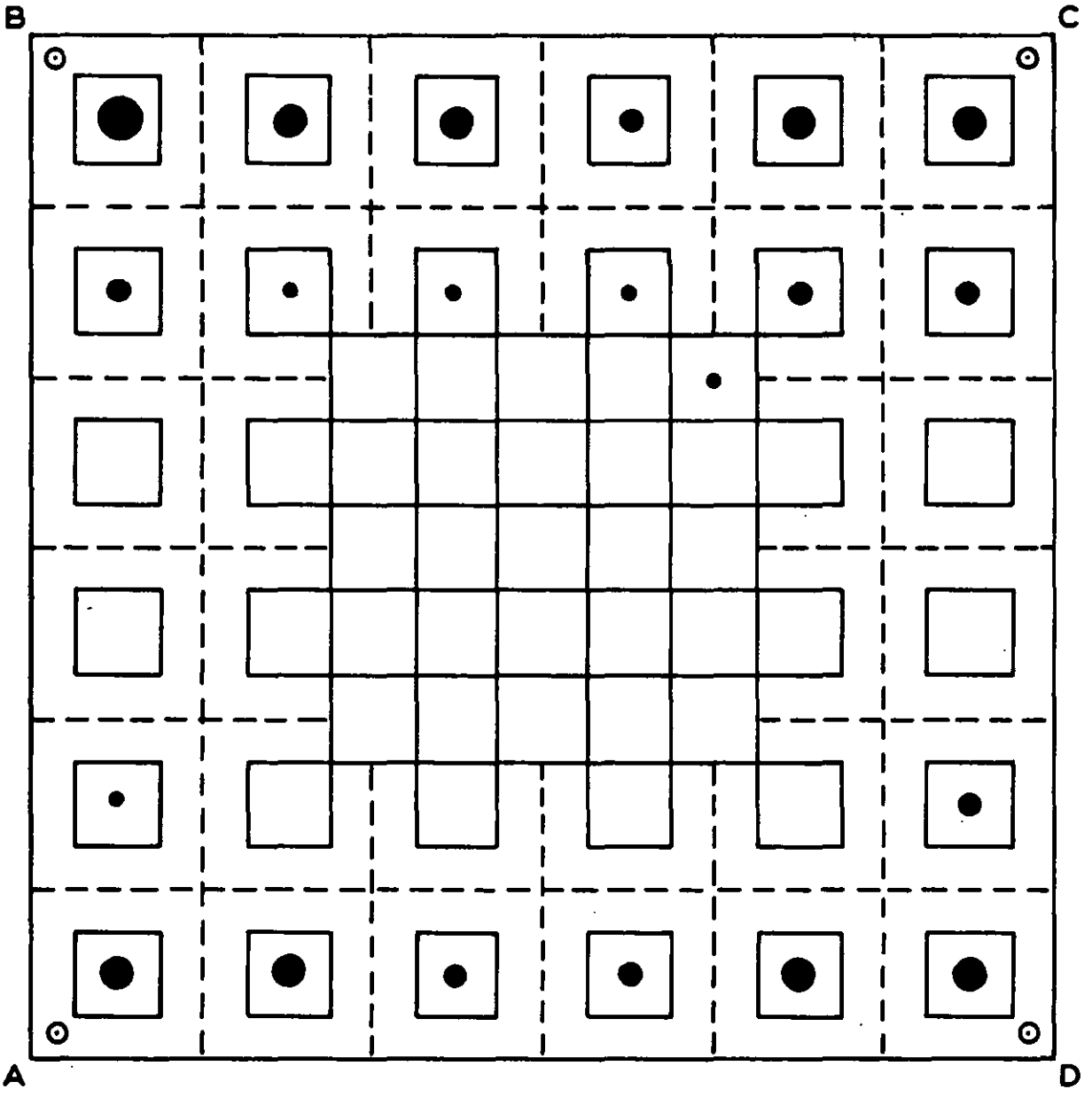


Make T

Type SPRAY, PENDENT

Level 2 ft.

Distribution number 12a.

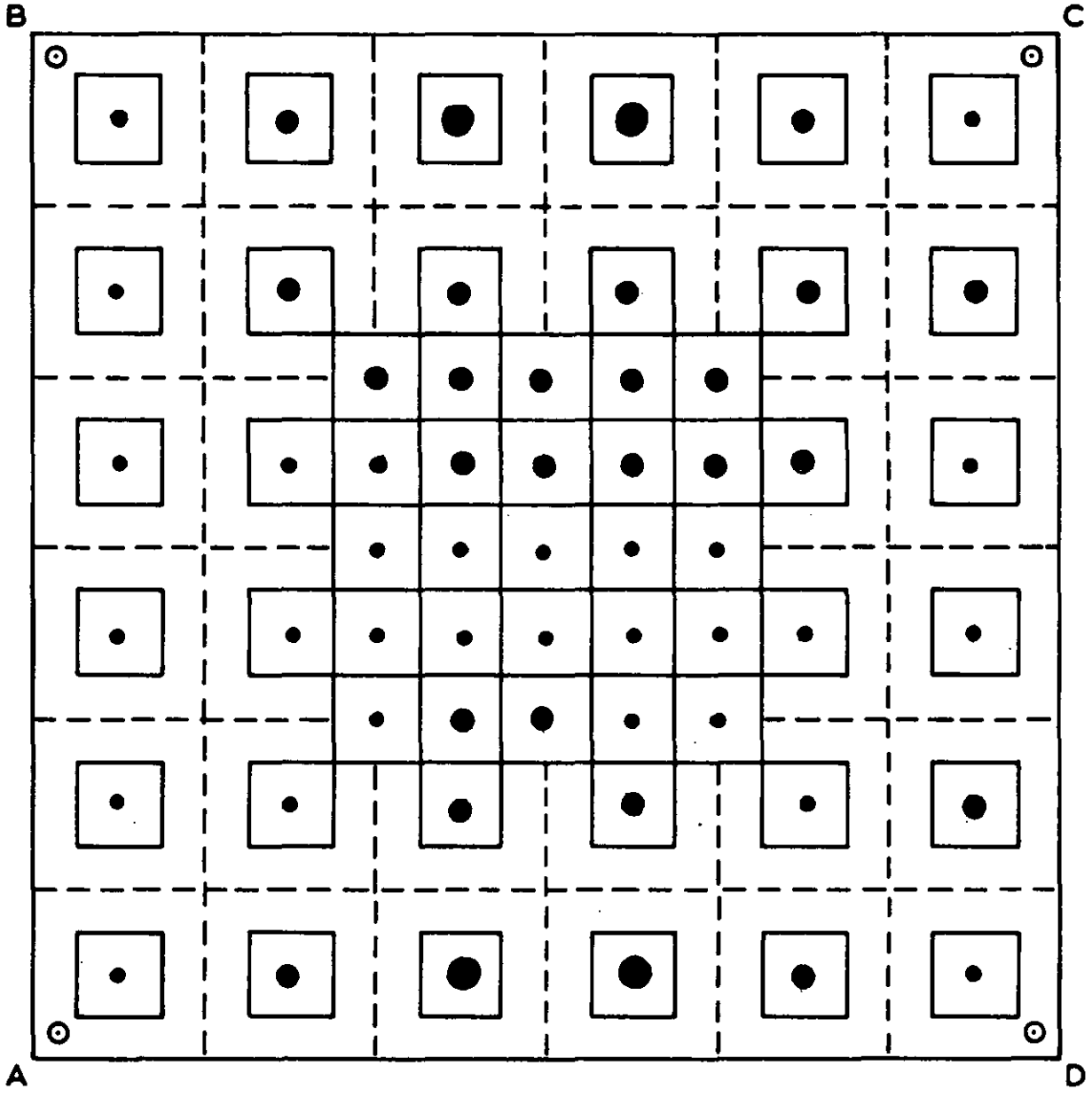


Make T

Type SPRAY, PENDENT

Level 4 ft.

Distribution number 12b

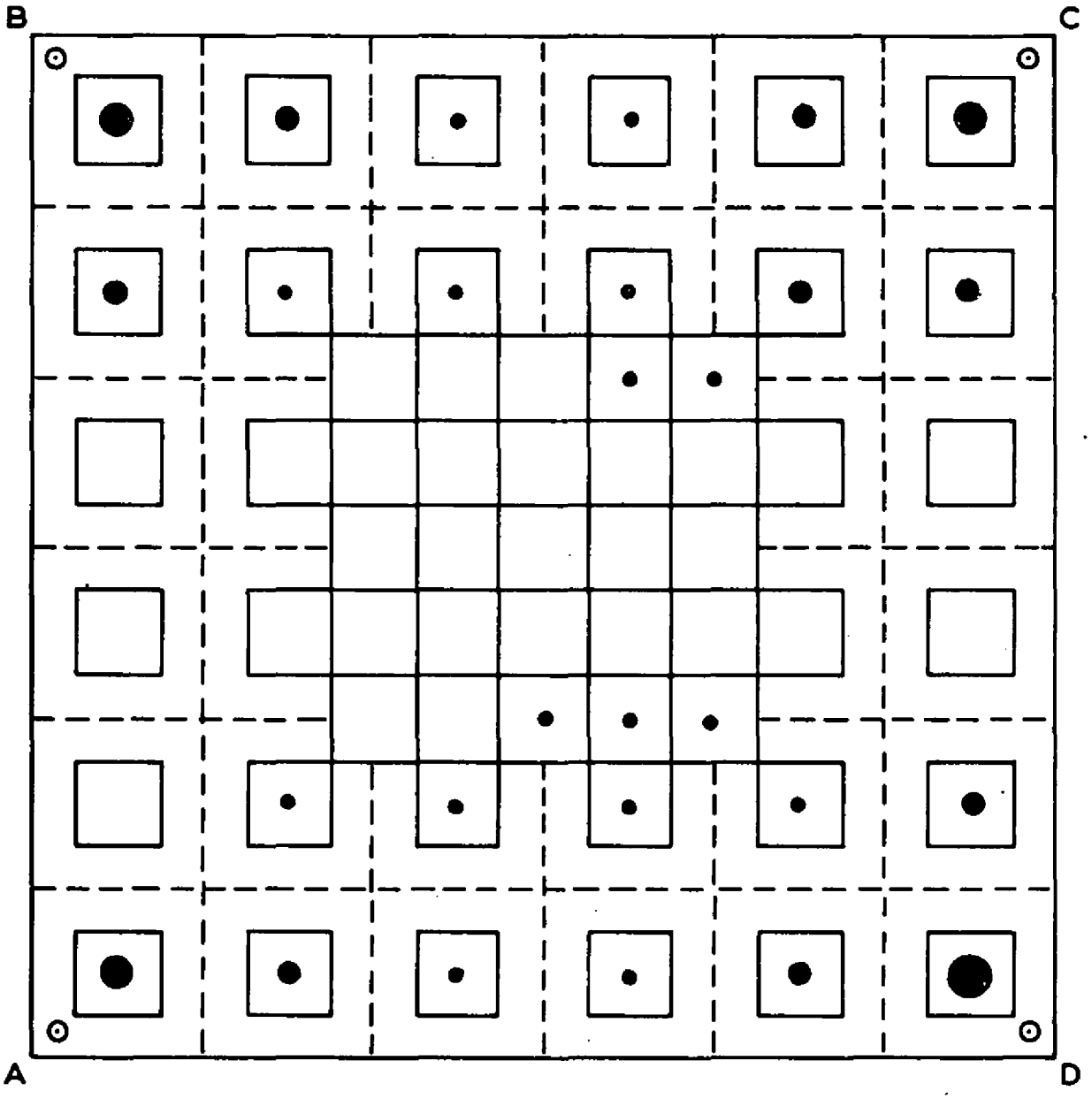


Make T

Type SPRAY, PENDENT

Level 12 ft.

Distribution number 12c.

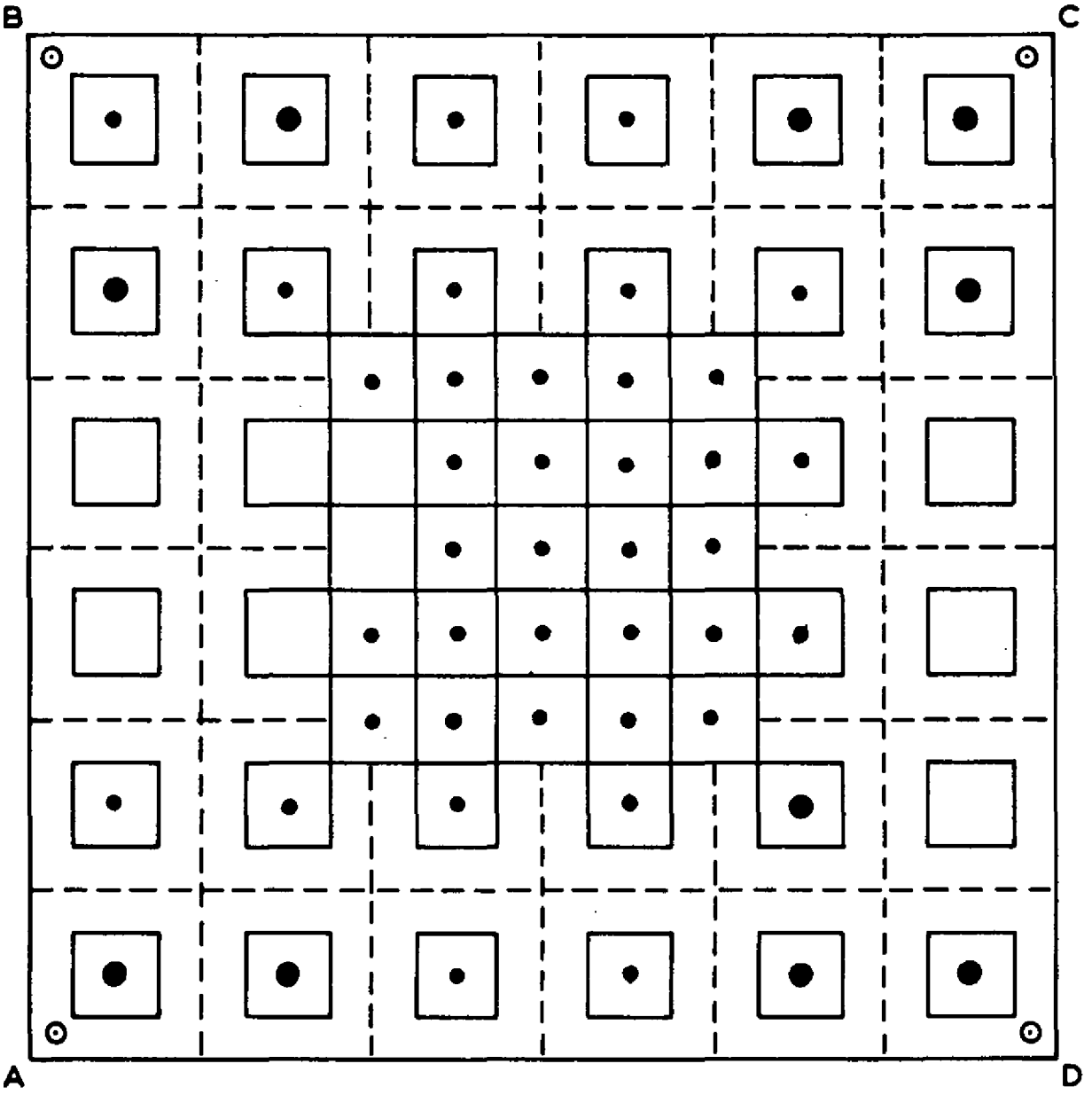


Make P

Type CONVENTIONAL, UPRIGHT

Level 2 ft.

Distribution number 13a.

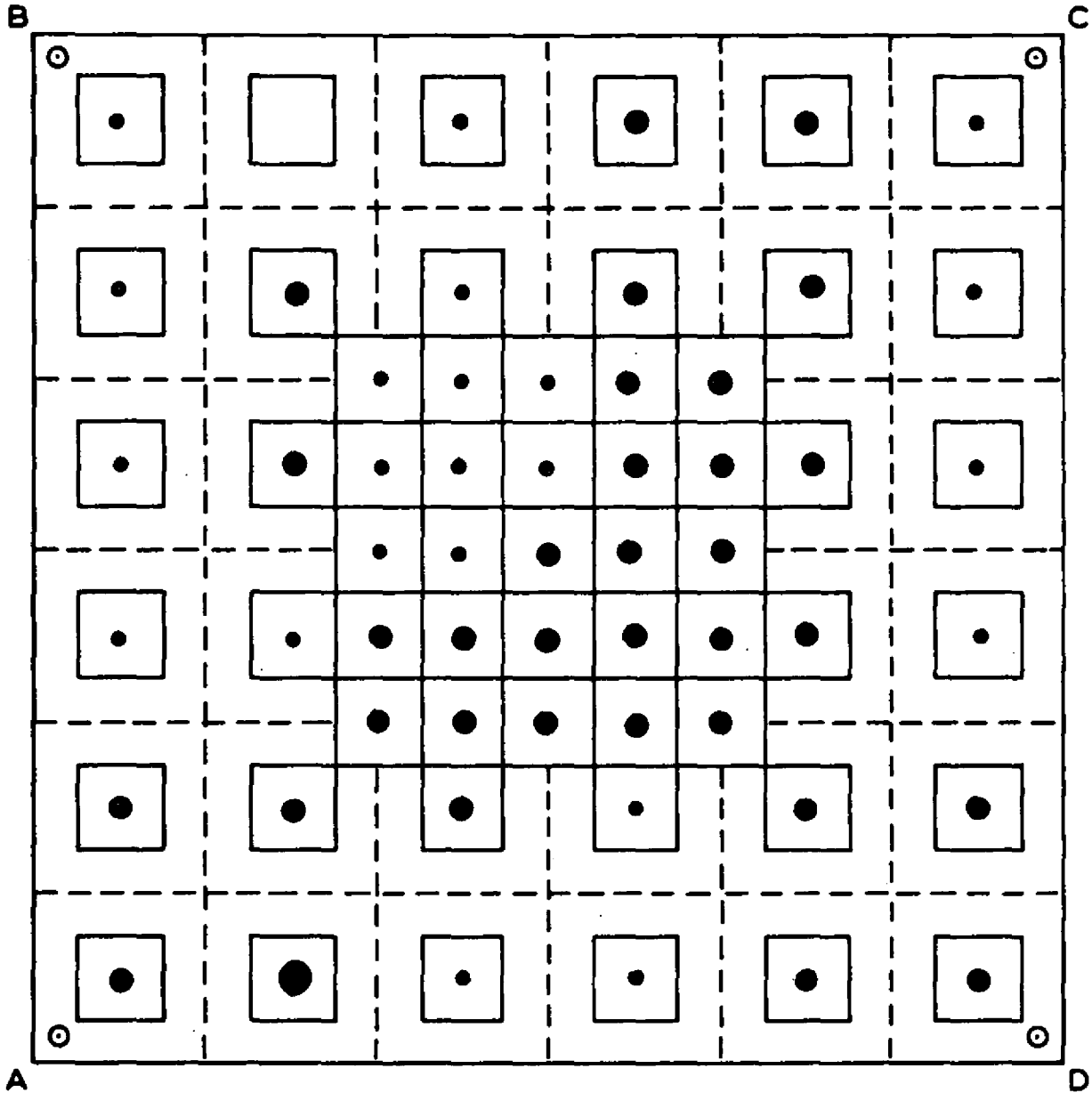


Make P

Type CONVENTIONAL, UPRIGHT

Level 4 ft.

Distribution number 13b.

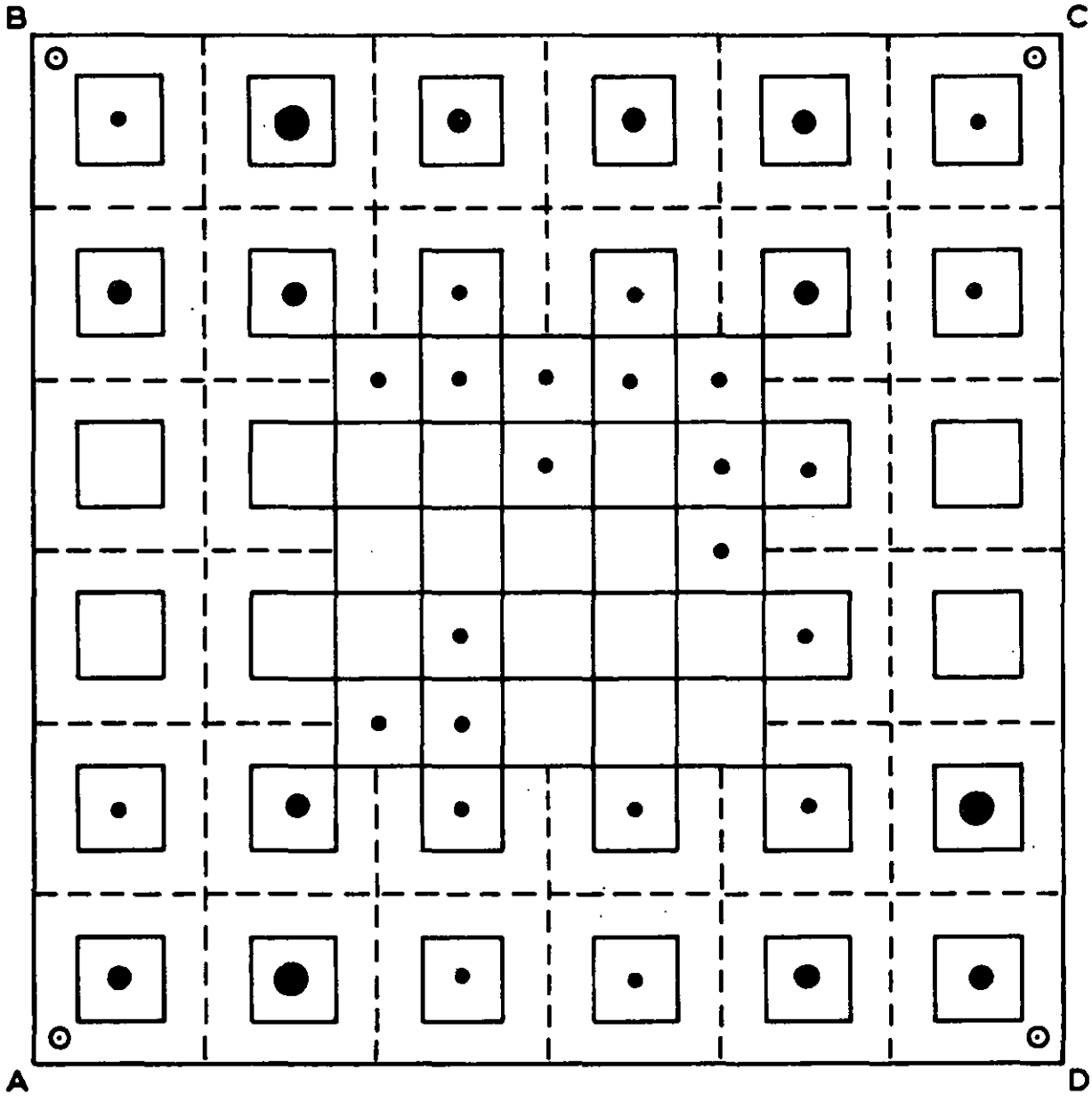


Make P

Type CONVENTIONAL UPRIGHT

Level 12 ft.

Distribution number 13c.

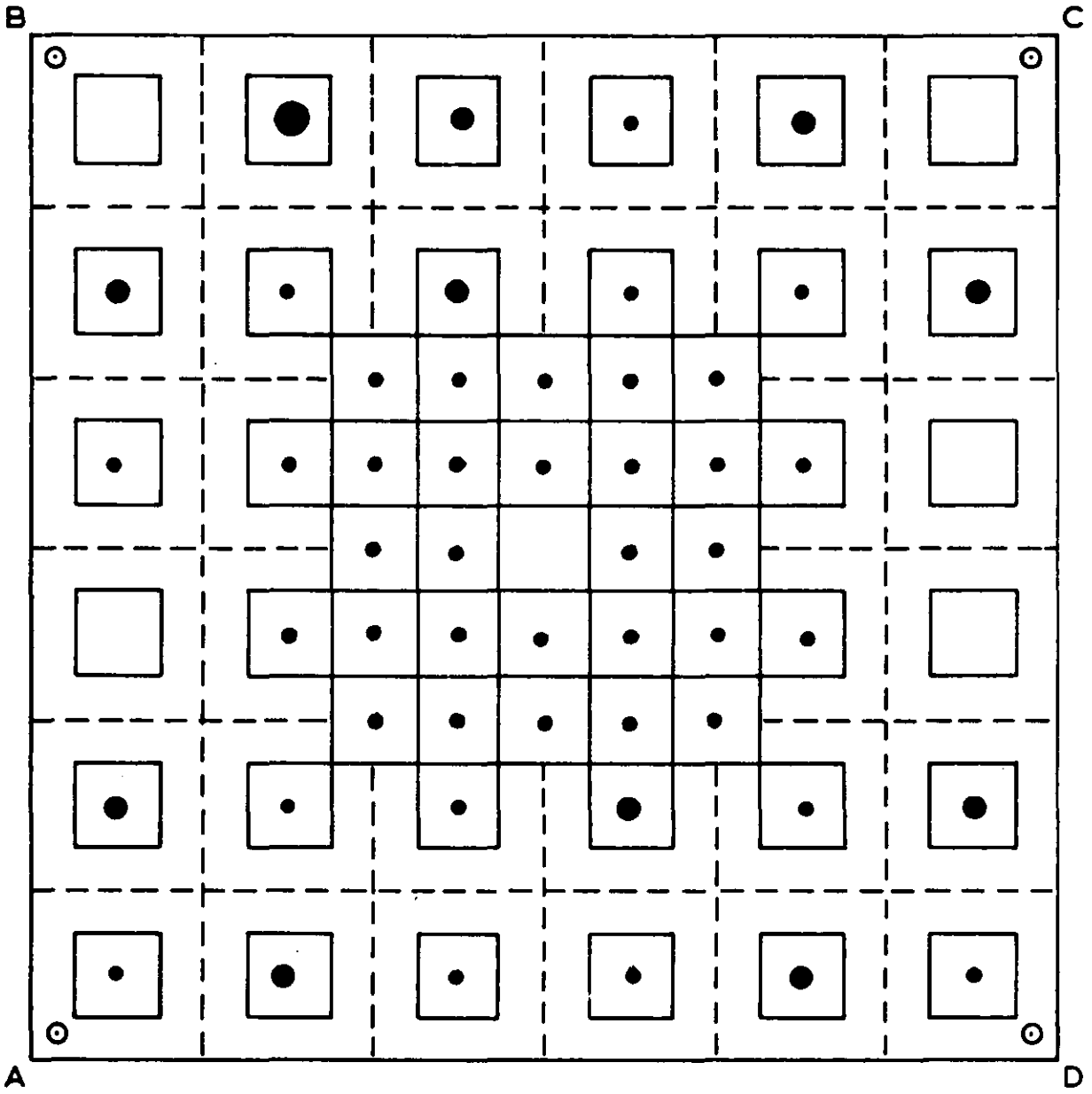


Make Q

Type CONVENTIONAL UPRIGHT

Level 2 ft.

Distribution number 14a.

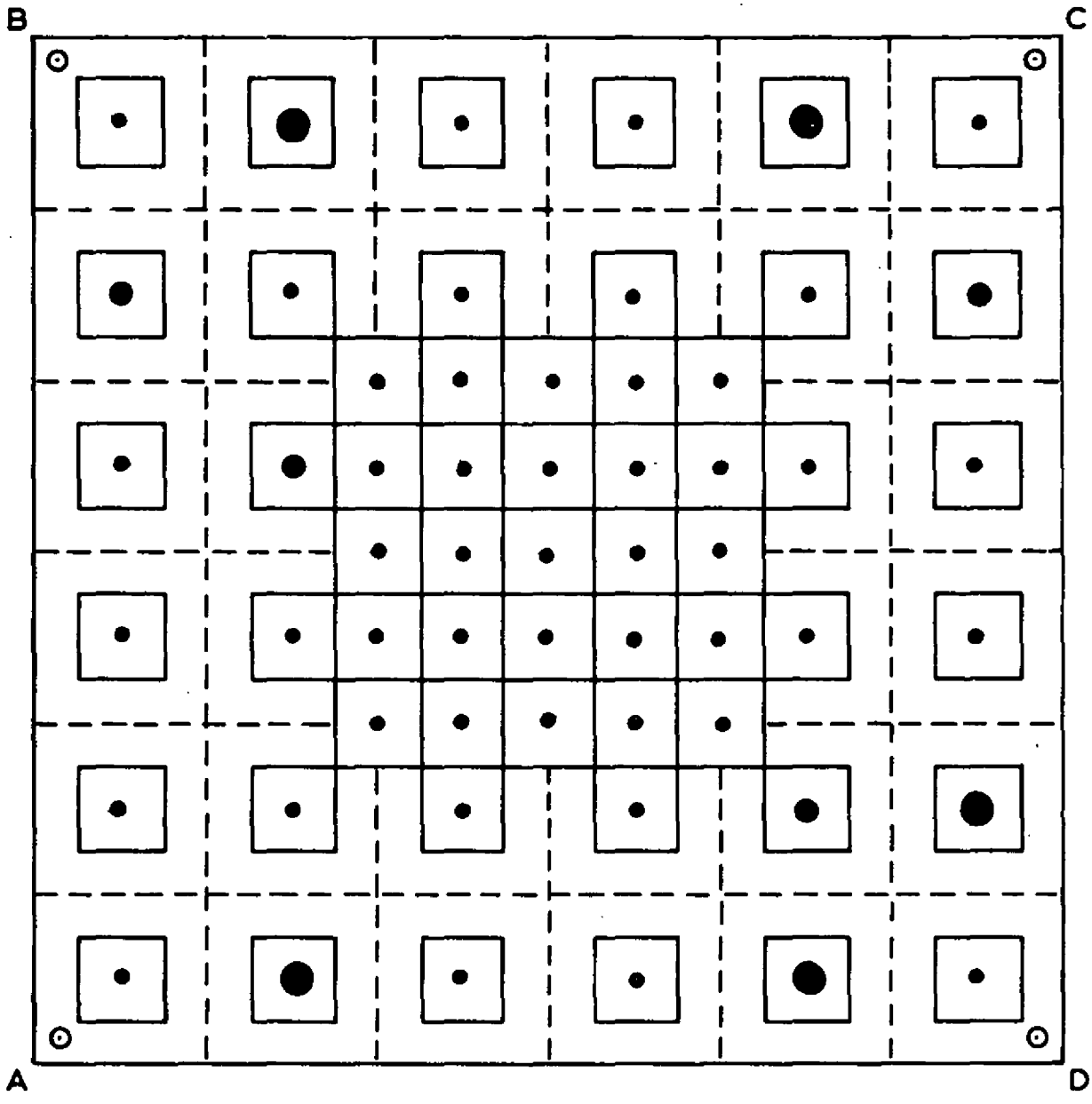


Make Q

Type CONVENTIONAL, UPRIGHT

Level 4 ft.

Distribution number 14b

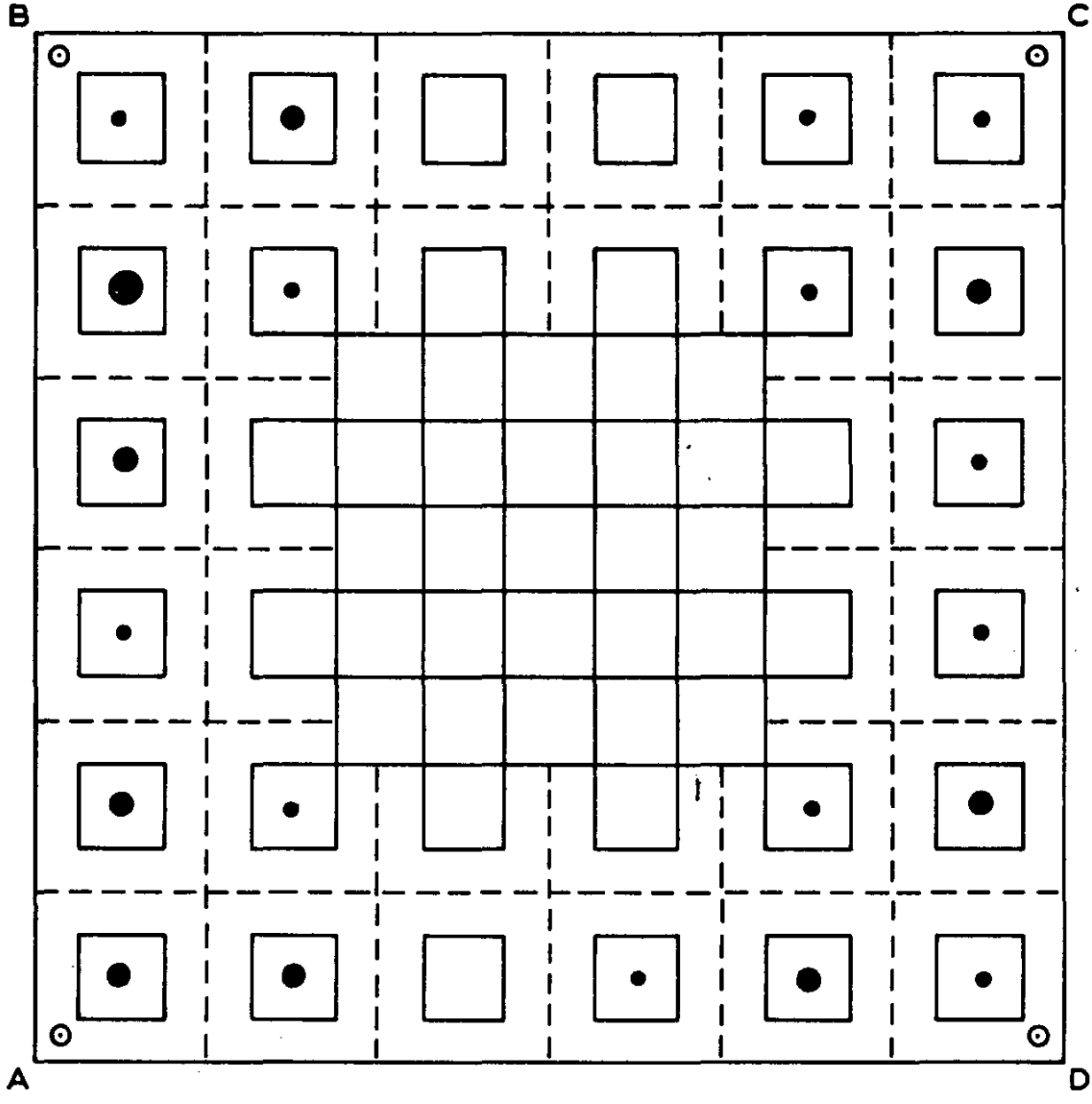


Make Q

Type CONVENTIONAL, UPRIGHT

Level 12 ft.

Distribution number 14c.

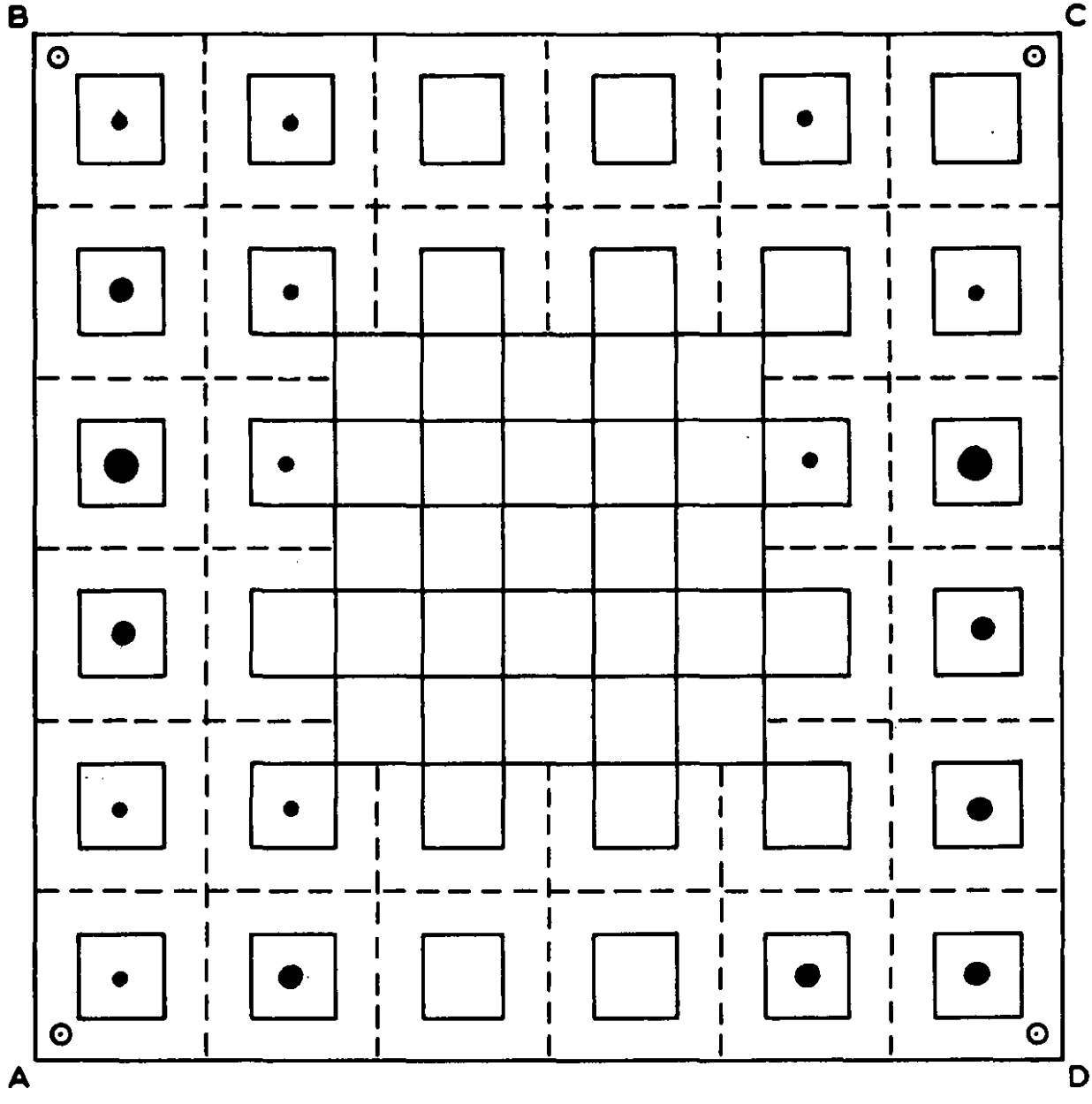


Make R

Type CONVENTIONAL, UPRIGHT

Level 2 ft.

Distribution number 15a.

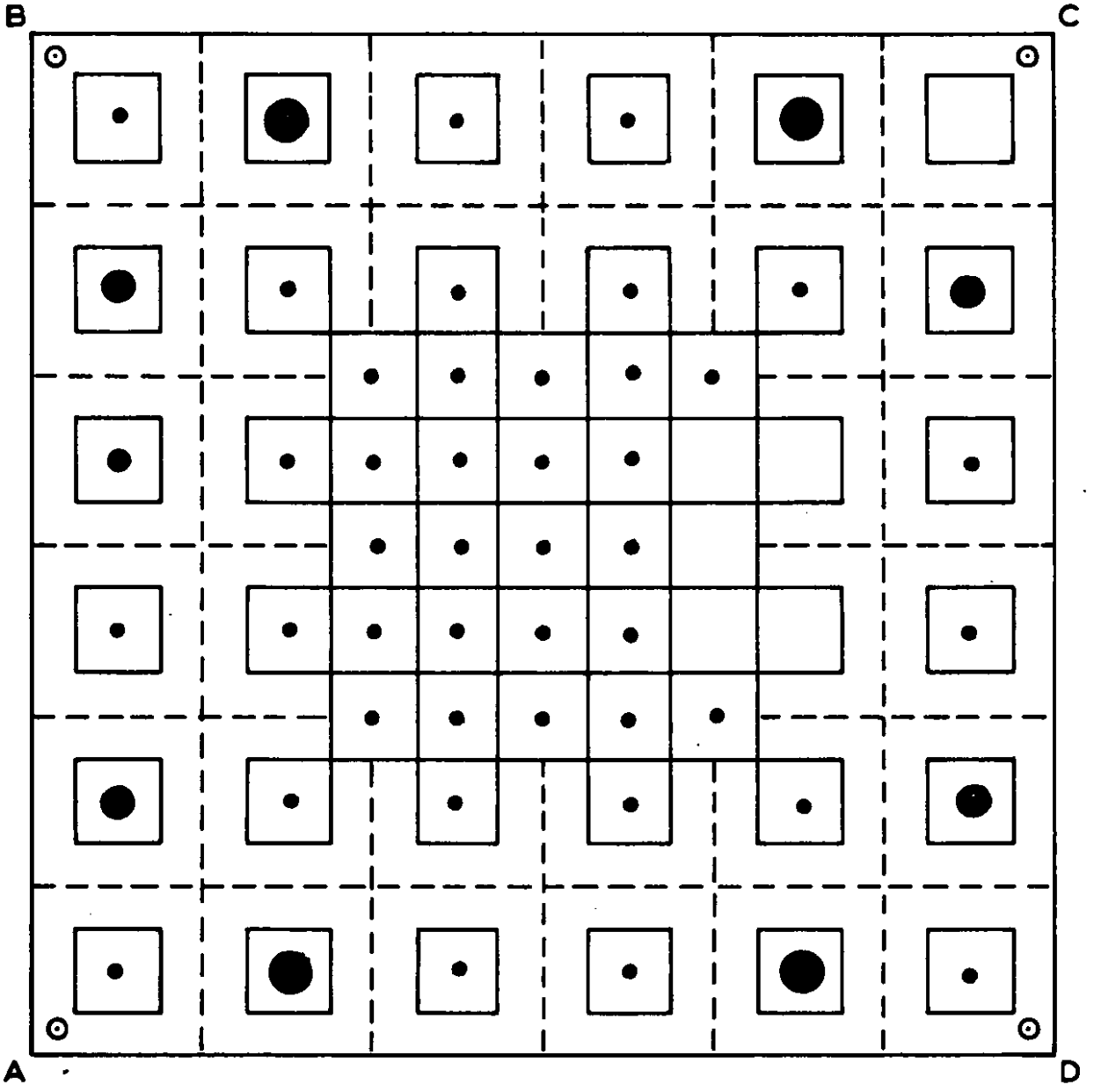


Make R

Type CONVENTIONAL, UPRIGHT

Level 4 ft.

Distribution number 15b.

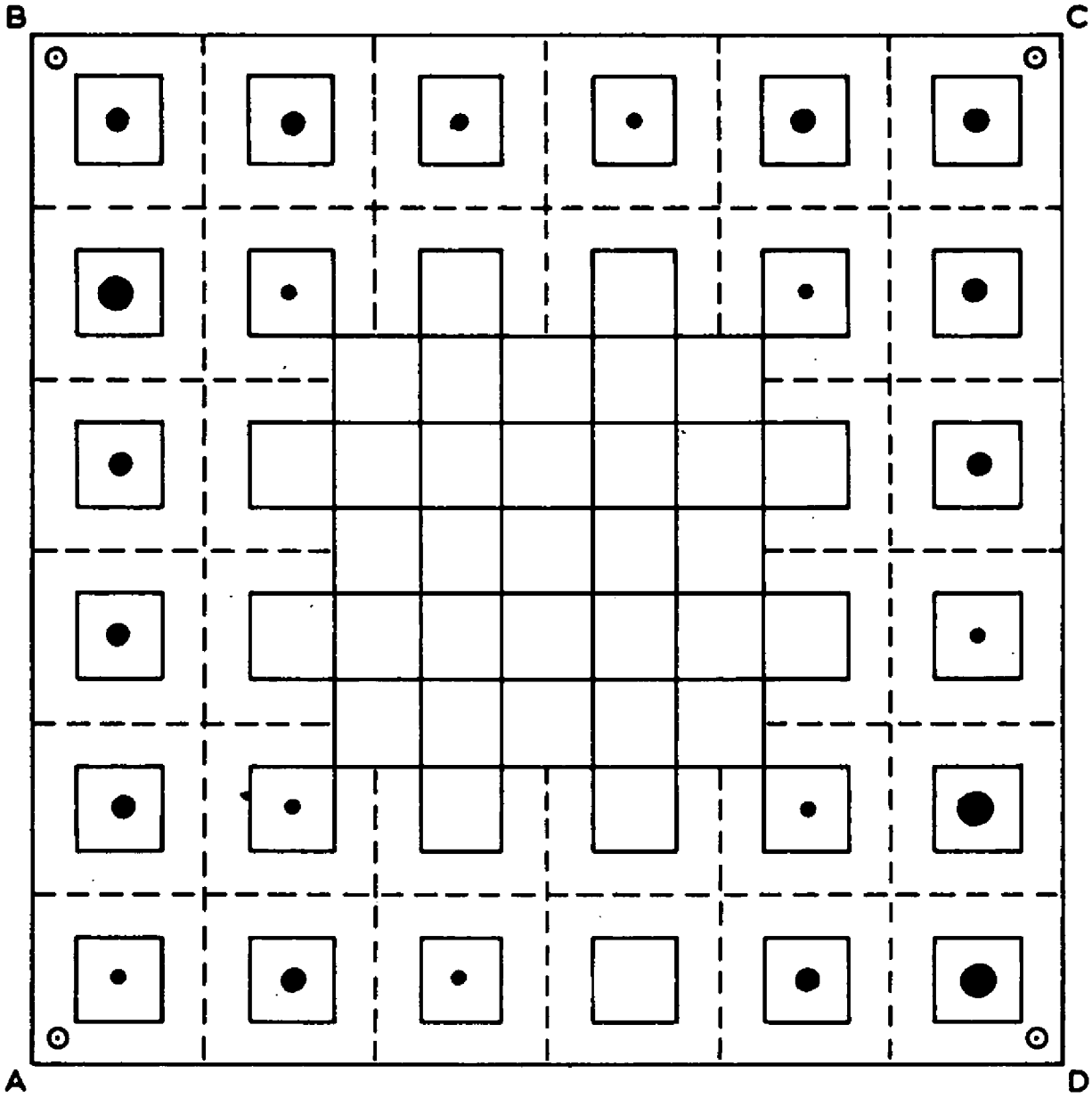


Make R

Type CONVENTIONAL, UPRIGHT

Level 12 ft.

Distribution number 15c.

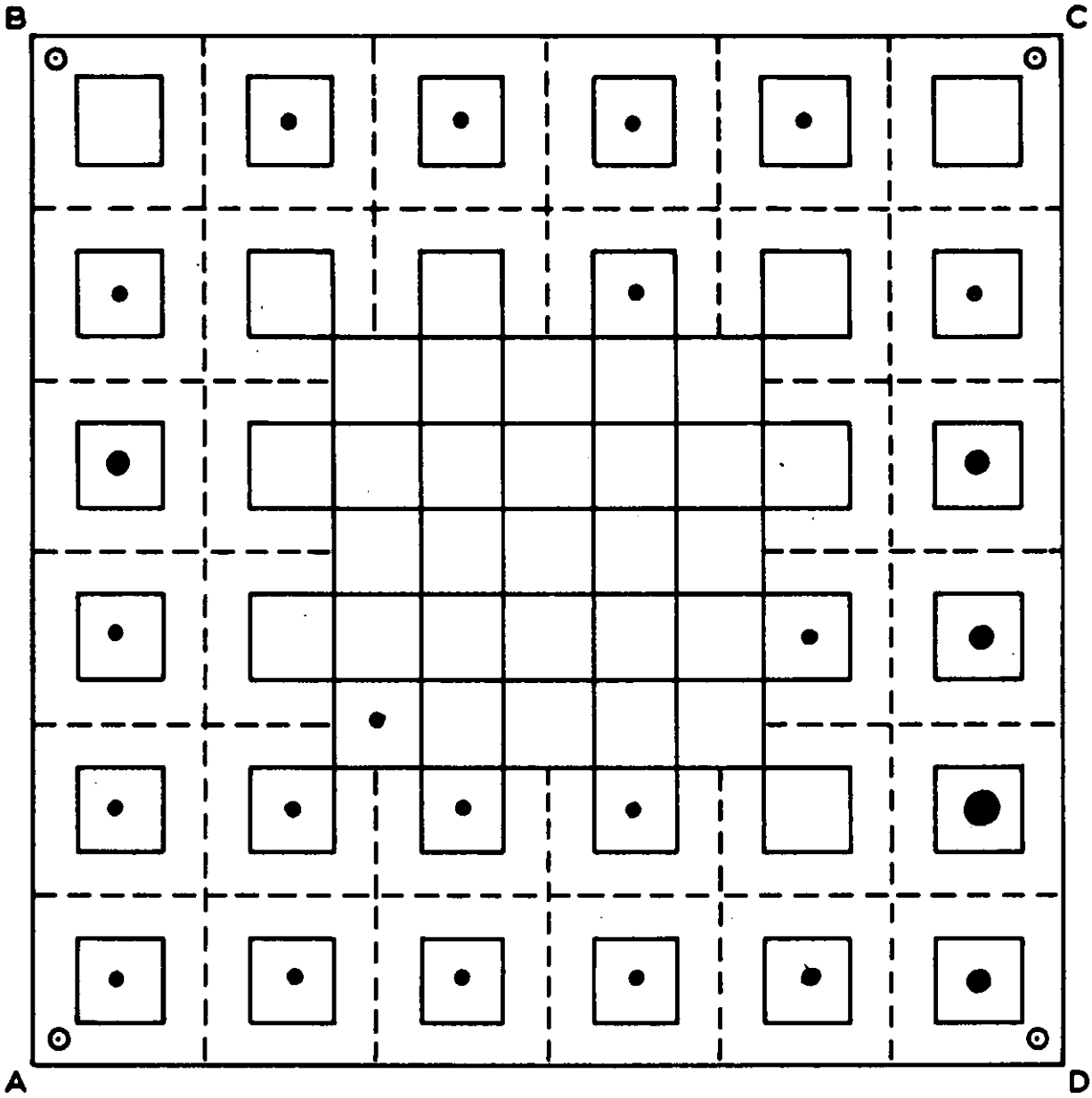


Make S

Type CONVENTIONAL, UPRIGHT

Level 2 ft.

Distribution number 16a.

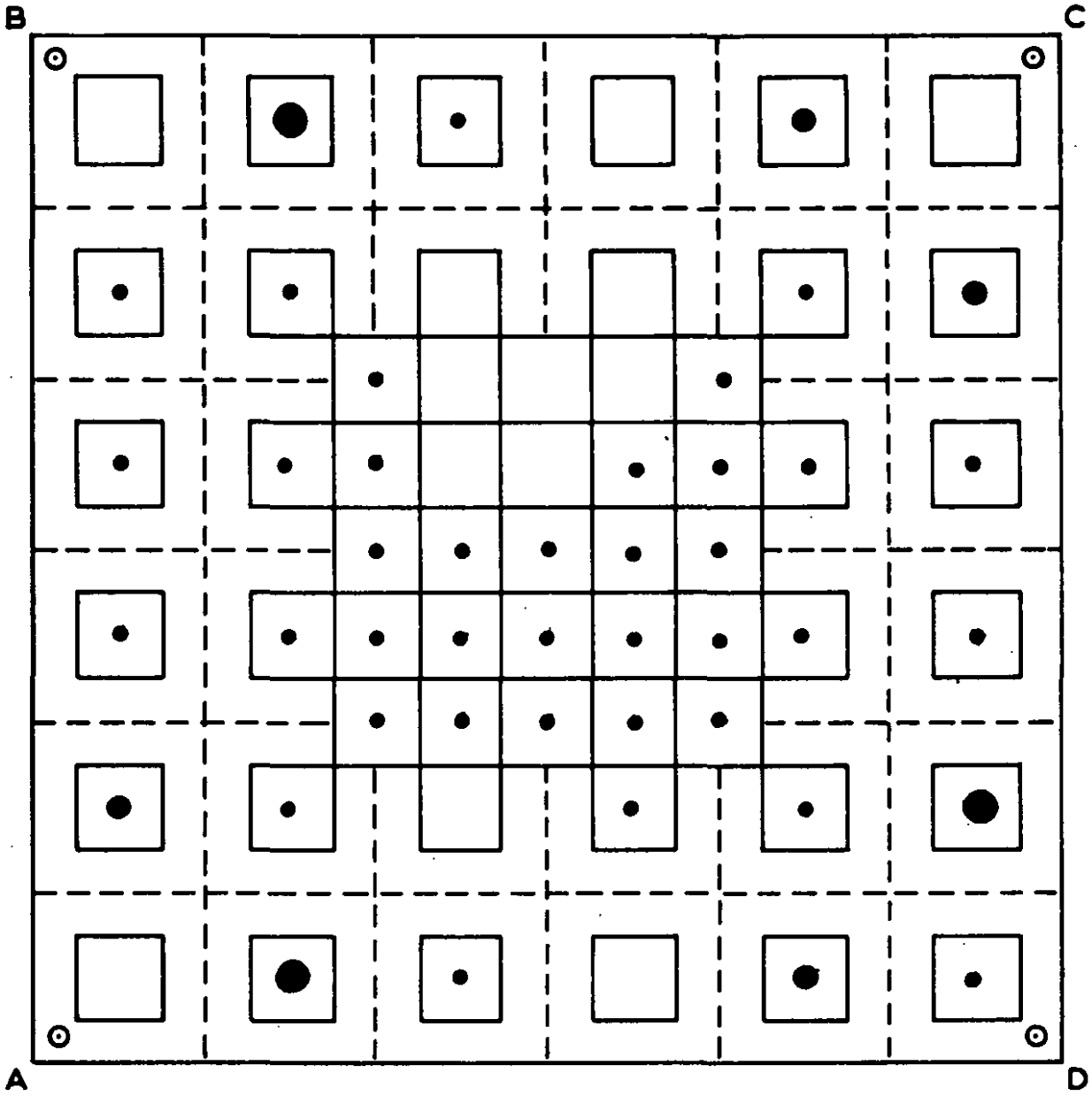


Make S

Type CONVENTIONAL, UPRIGHT

Level 4 ft.

Distribution number 16b

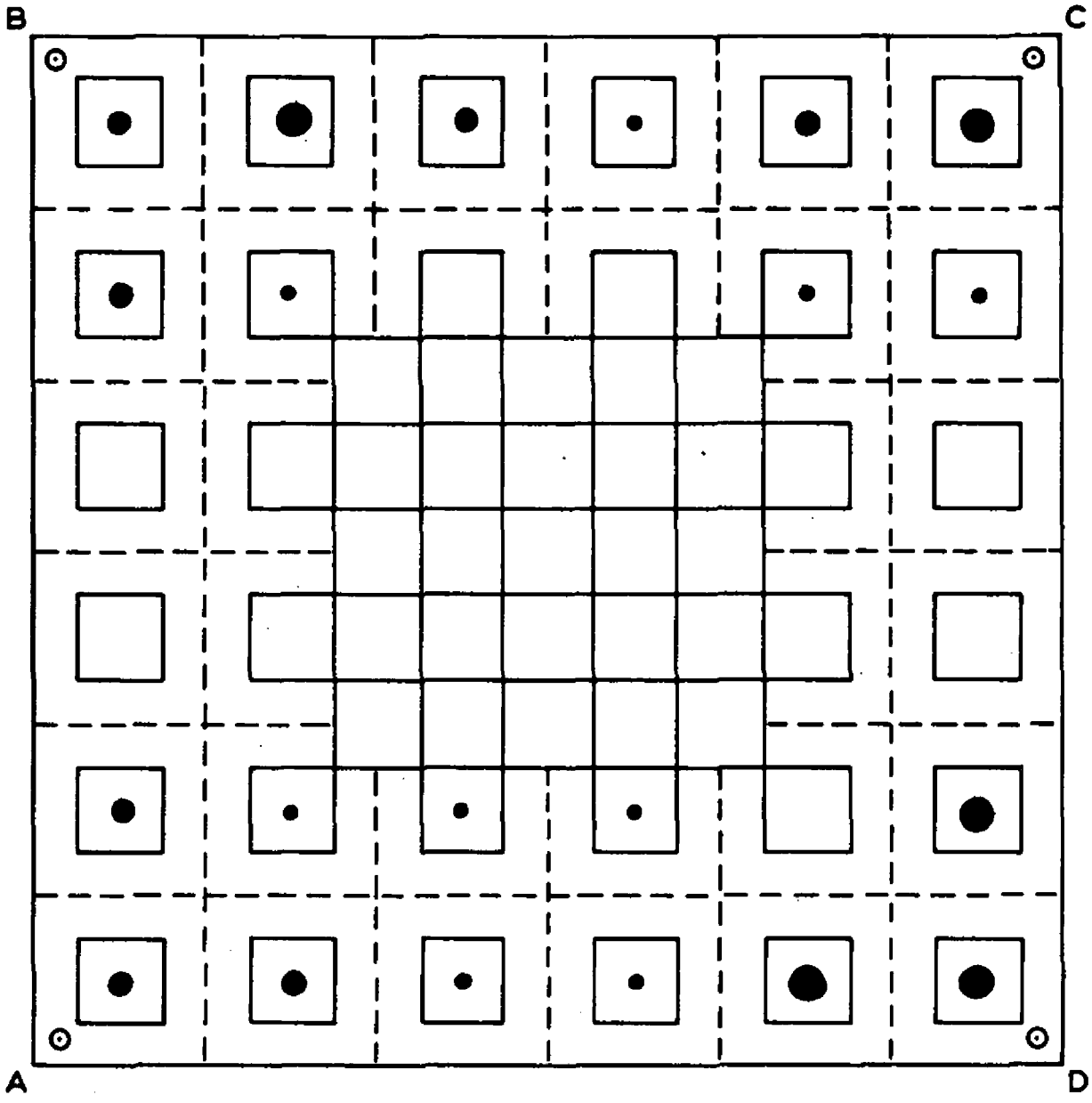


Make S

Type CONVENTIONAL, UPRIGHT

Level 12 ft.

Distribution number 16c.

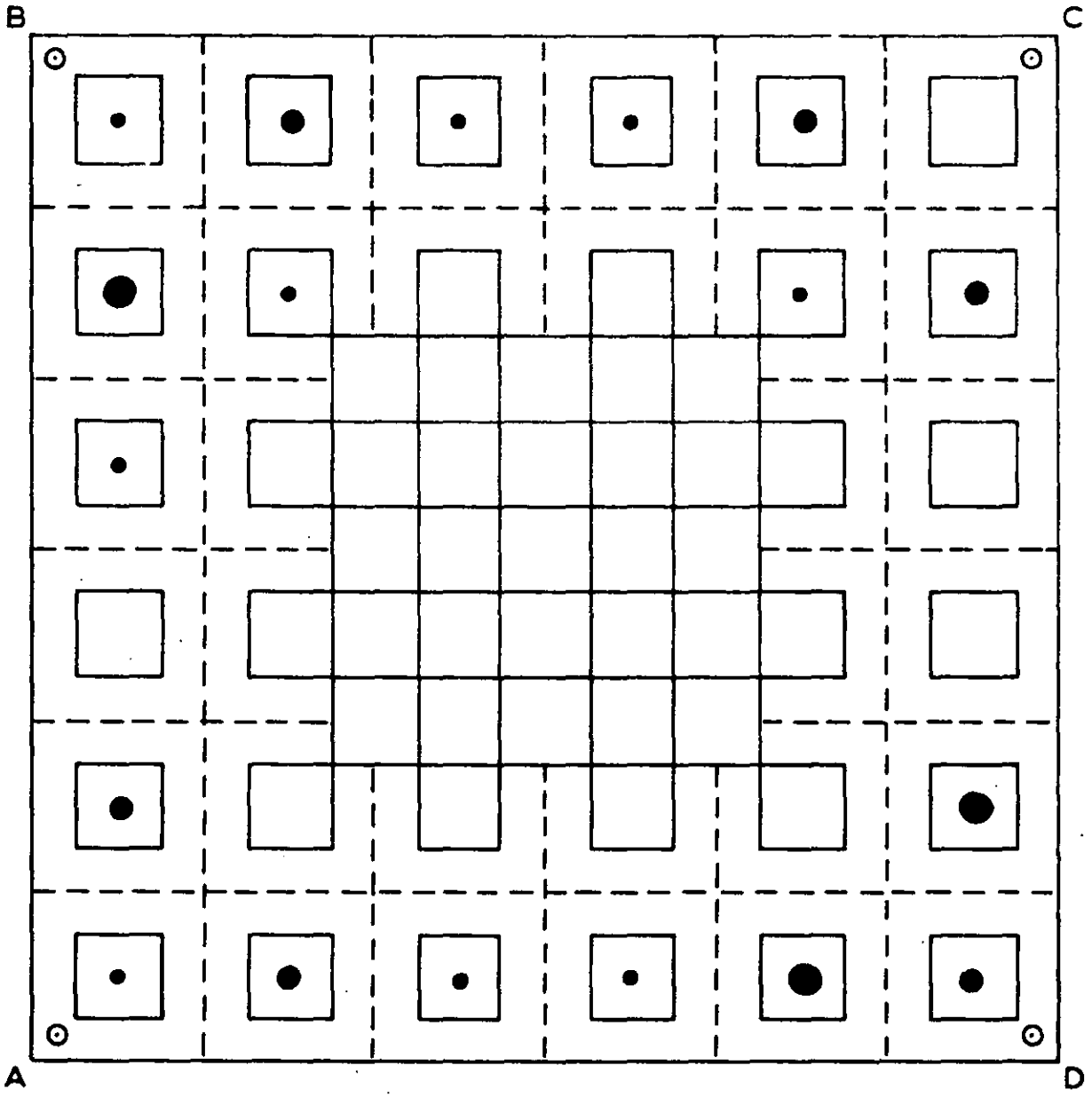


Make T

Type CONVENTIONAL, UPRIGHT

Level 2 ft.

Distribution number 17a.

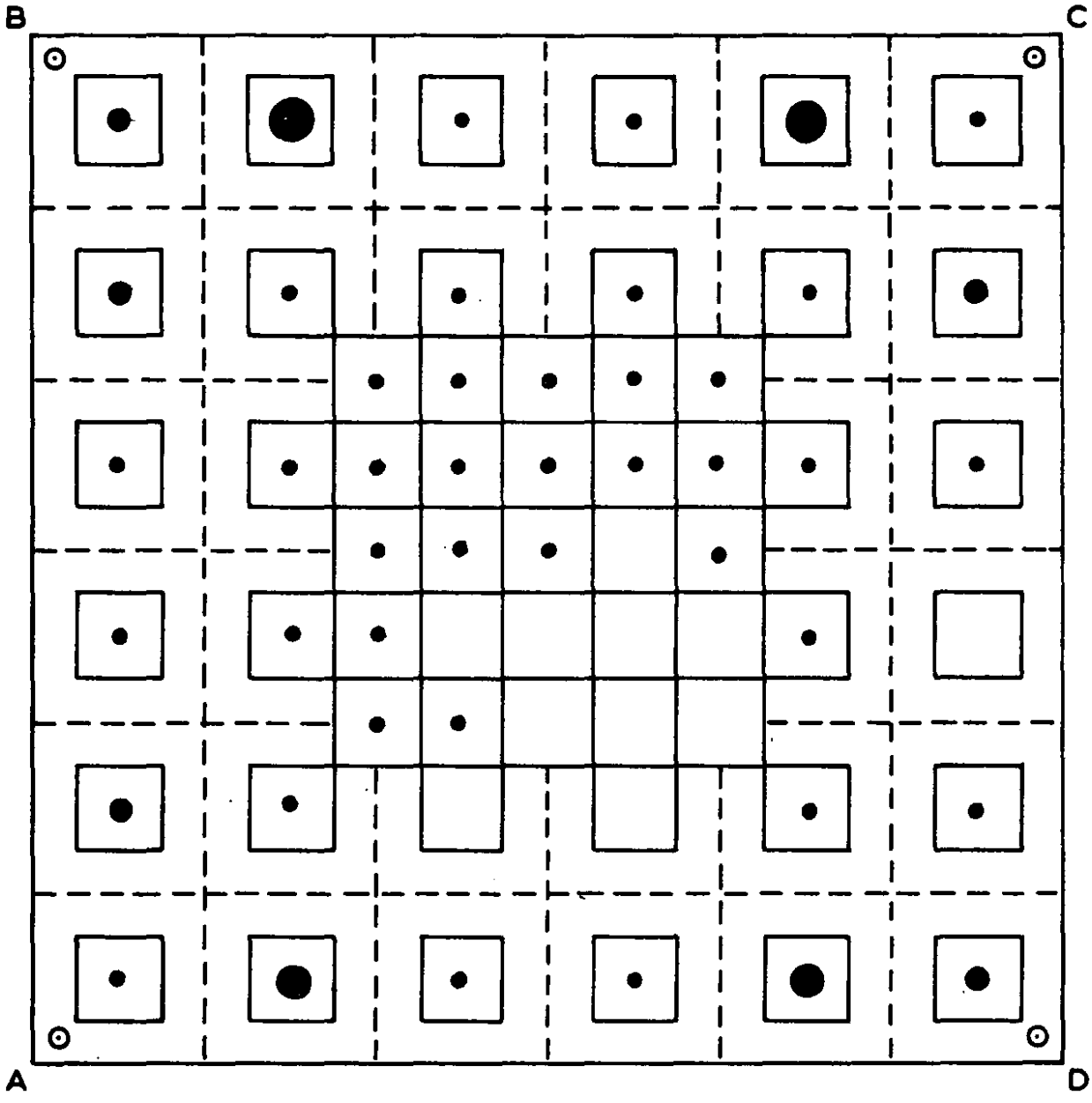


Make T

Type CONVENTIONAL, UPRIGHT

Level 4 ft.

Distribution number 17b.

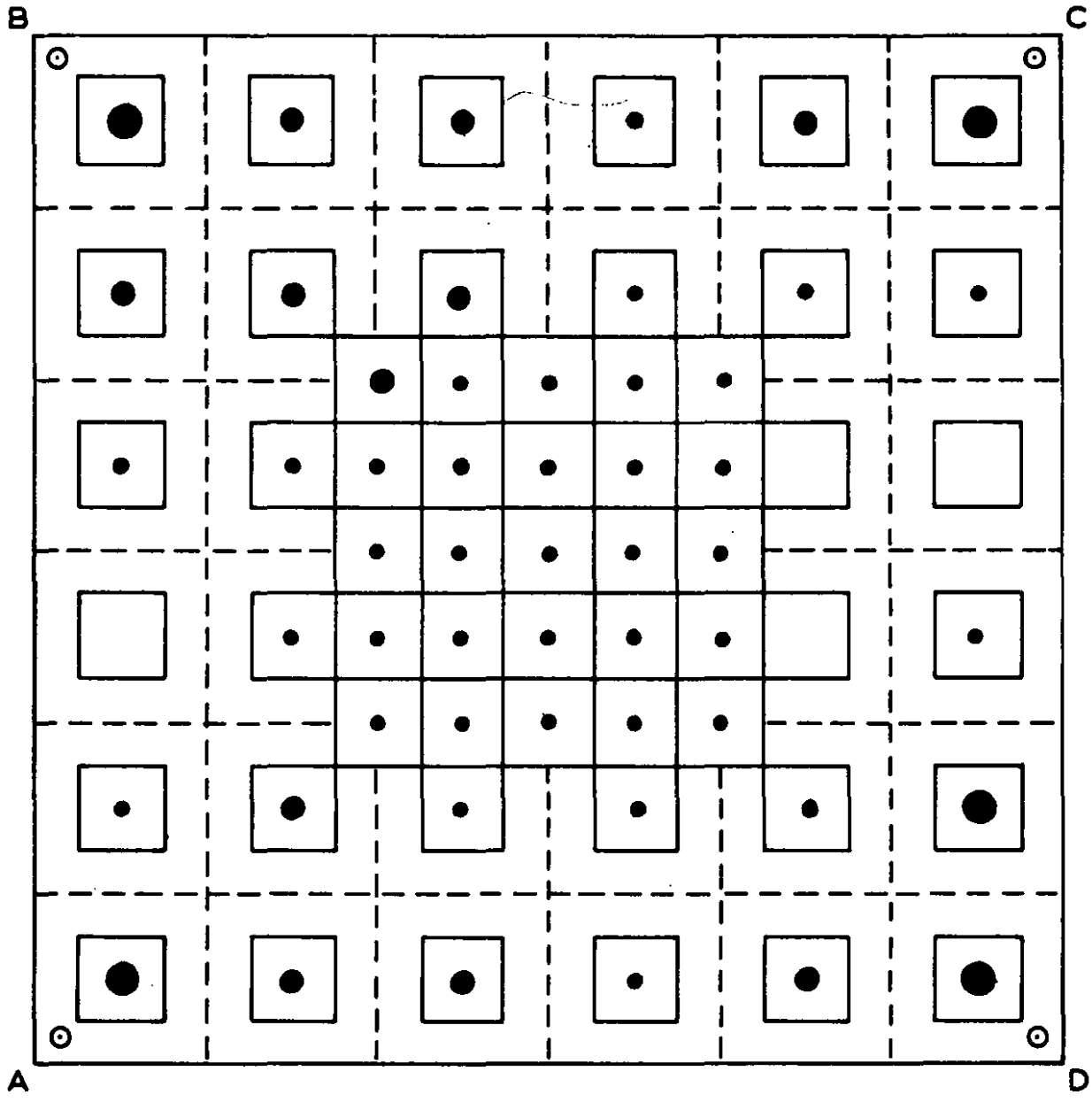


Make T

Type CONVENTIONAL, UPRIGHT

Level 12 ft.

Distribution number 17c.

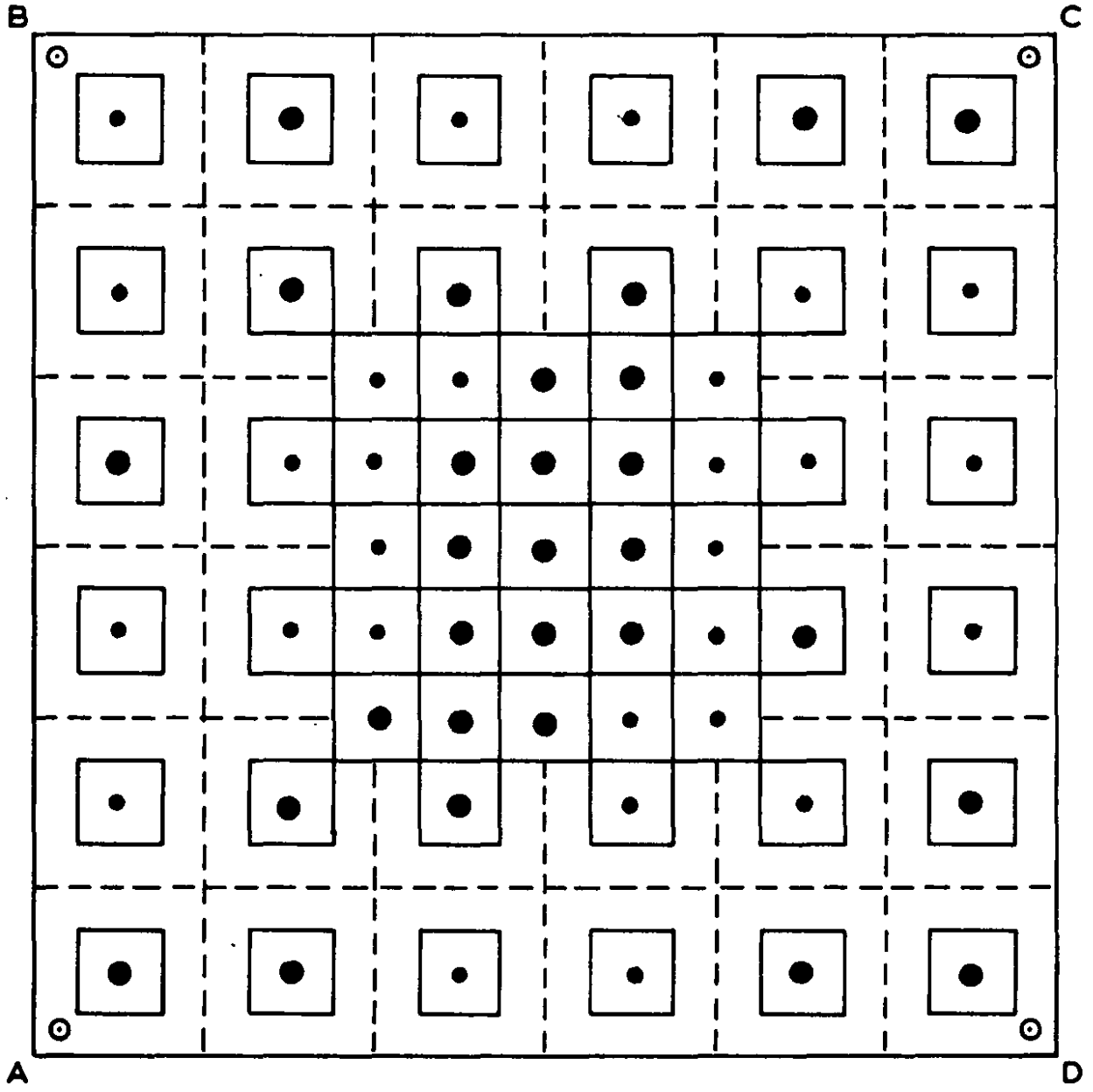


Make P

Type CONVENTIONAL, PENDENT

Level 2 ft.

Distribution number 18a.

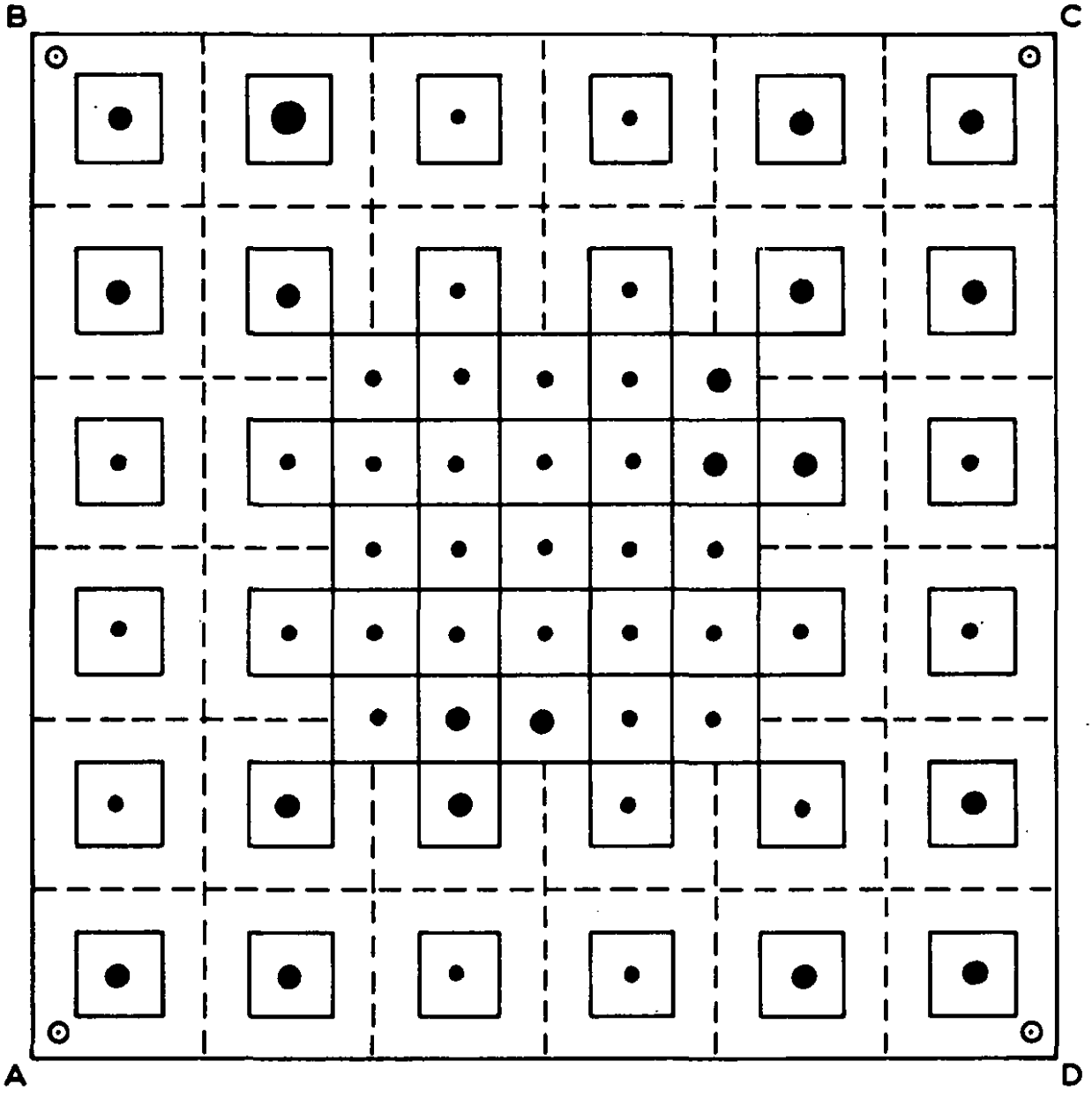


Make P

Type CONVENTIONAL, PENDENT

Level 4 ft.

Distribution number 18b

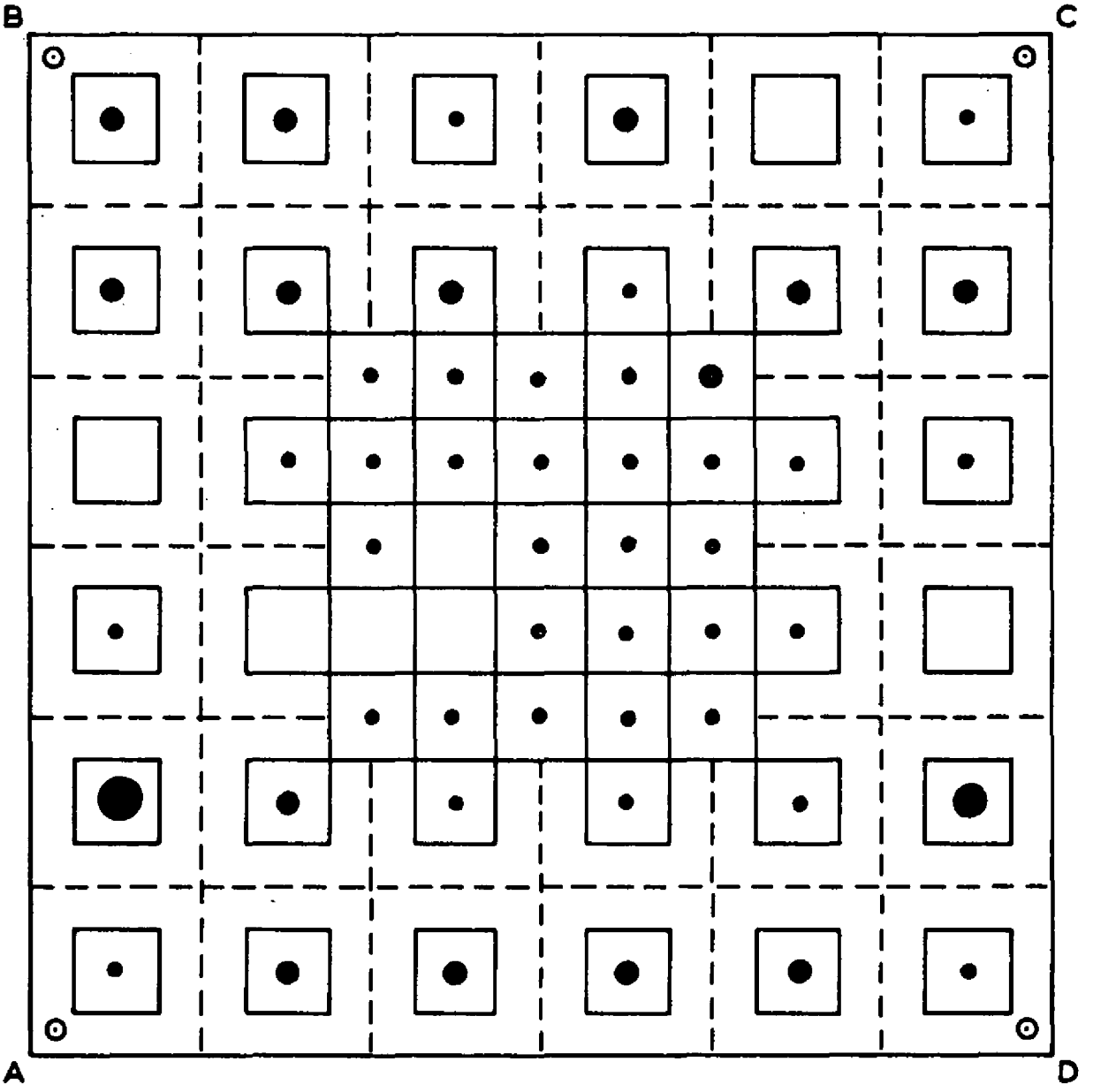


Make P

Type CONVENTIONAL, PENDENT

Level 12 ft.

Distribution number 18c.

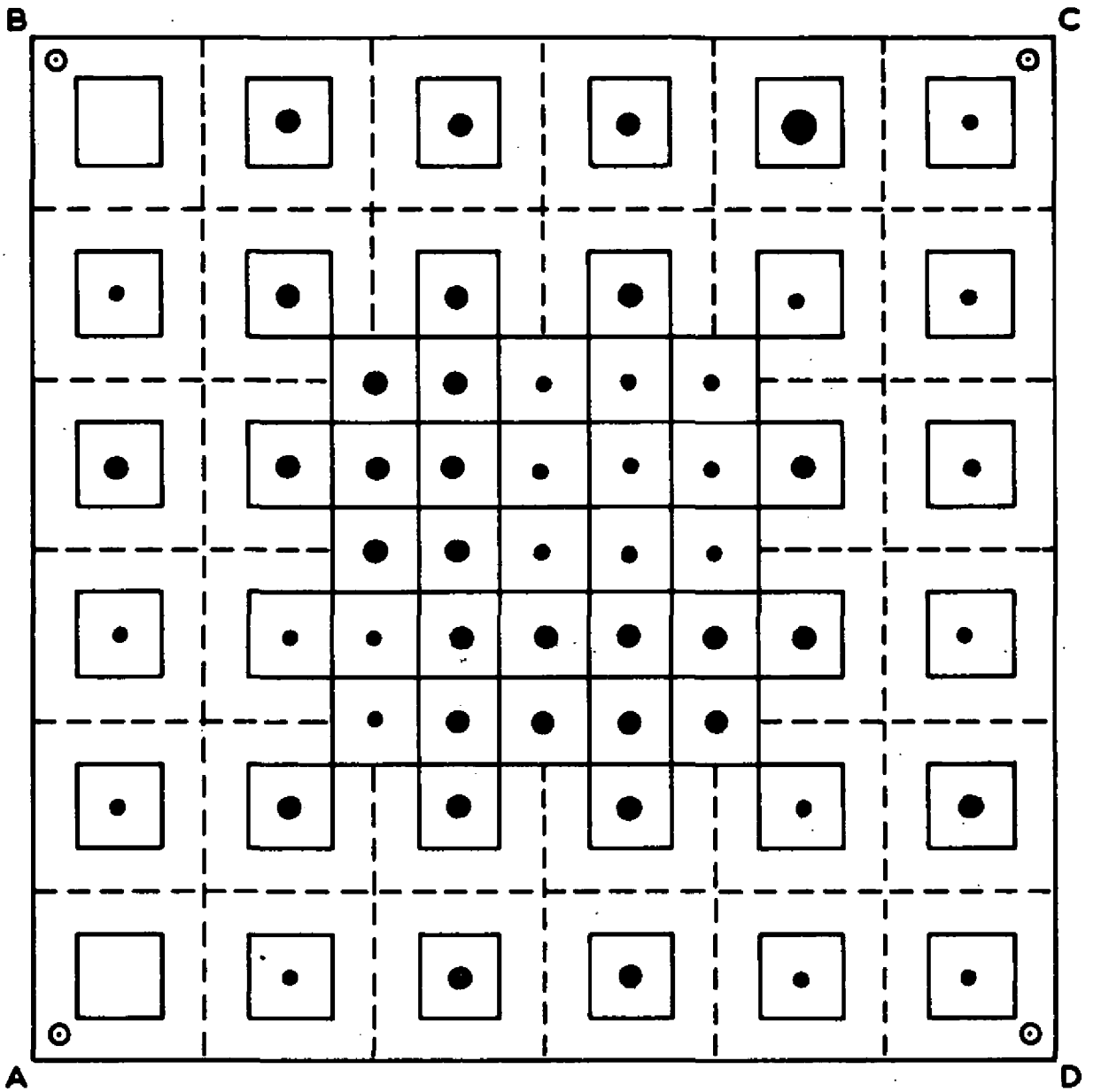


Make Q

Type CONVENTIONAL, PENDENT

Level 2 ft.

Distribution number 19a.

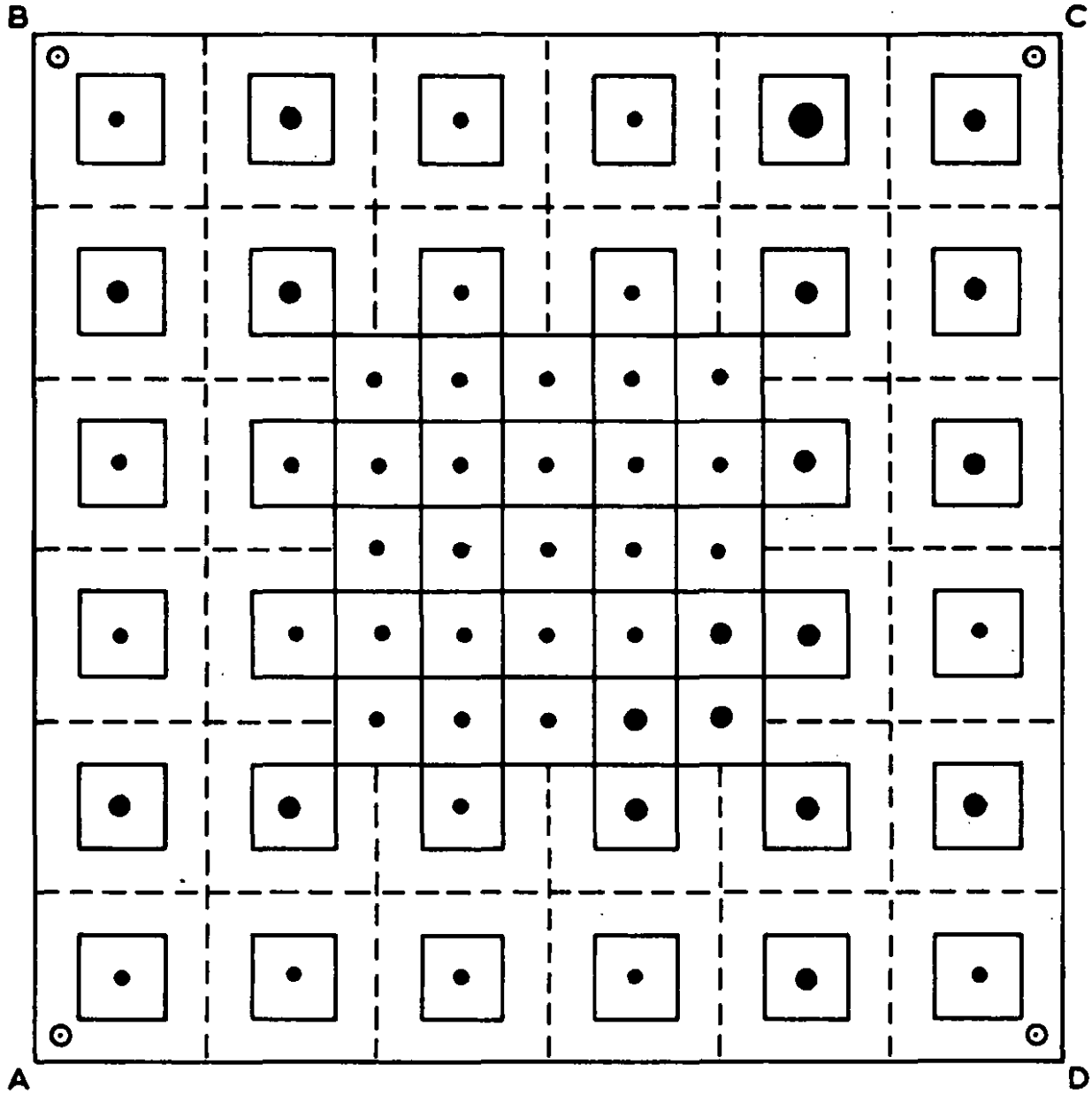


Make Q

Type CONVENTIONAL, PENDENT

Level 4 ft.

Distribution number 19b.

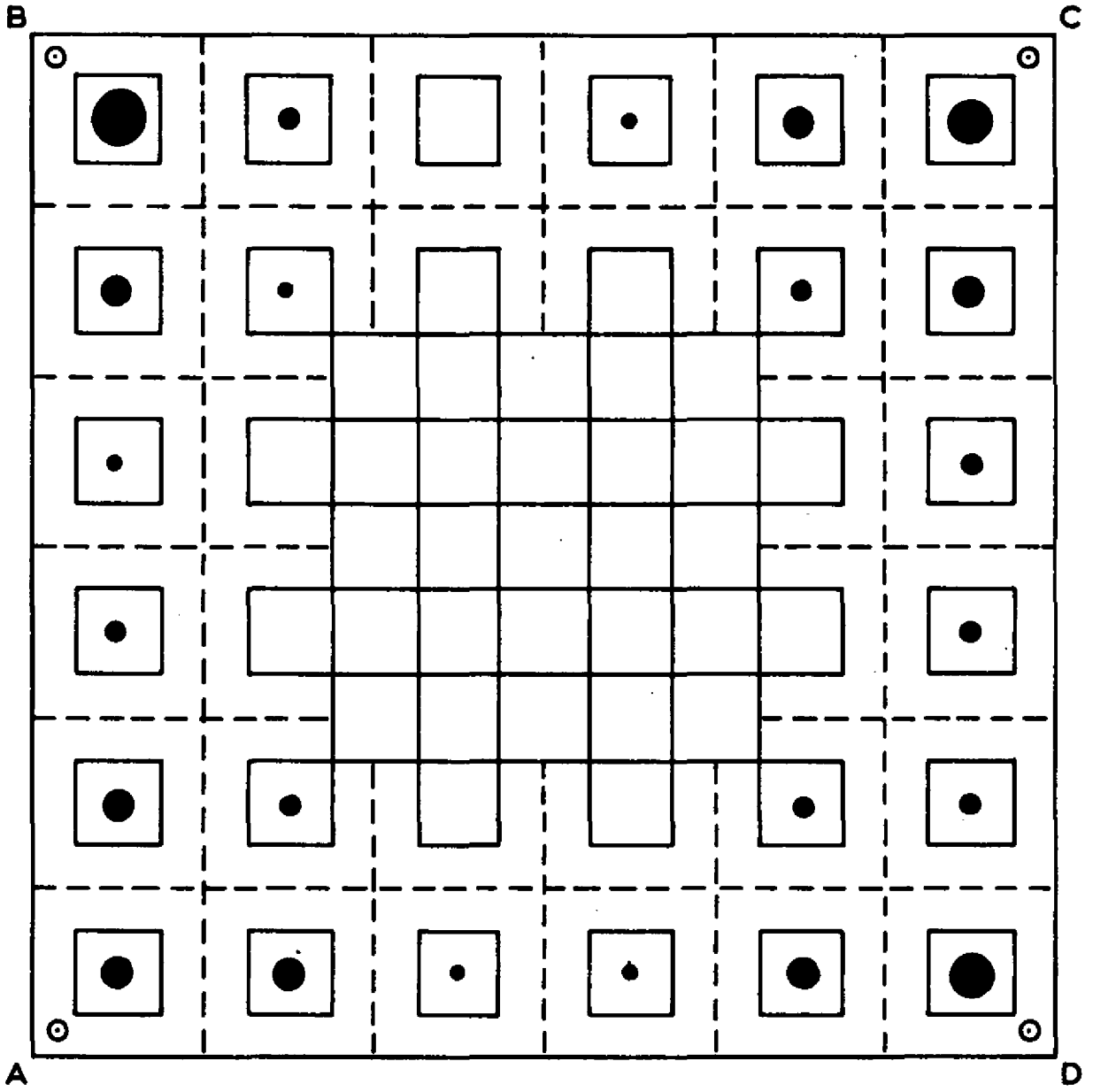


Make Q

Type CONVENTIONAL, PENDENT

Level 12 ft.

Distribution number 19c.

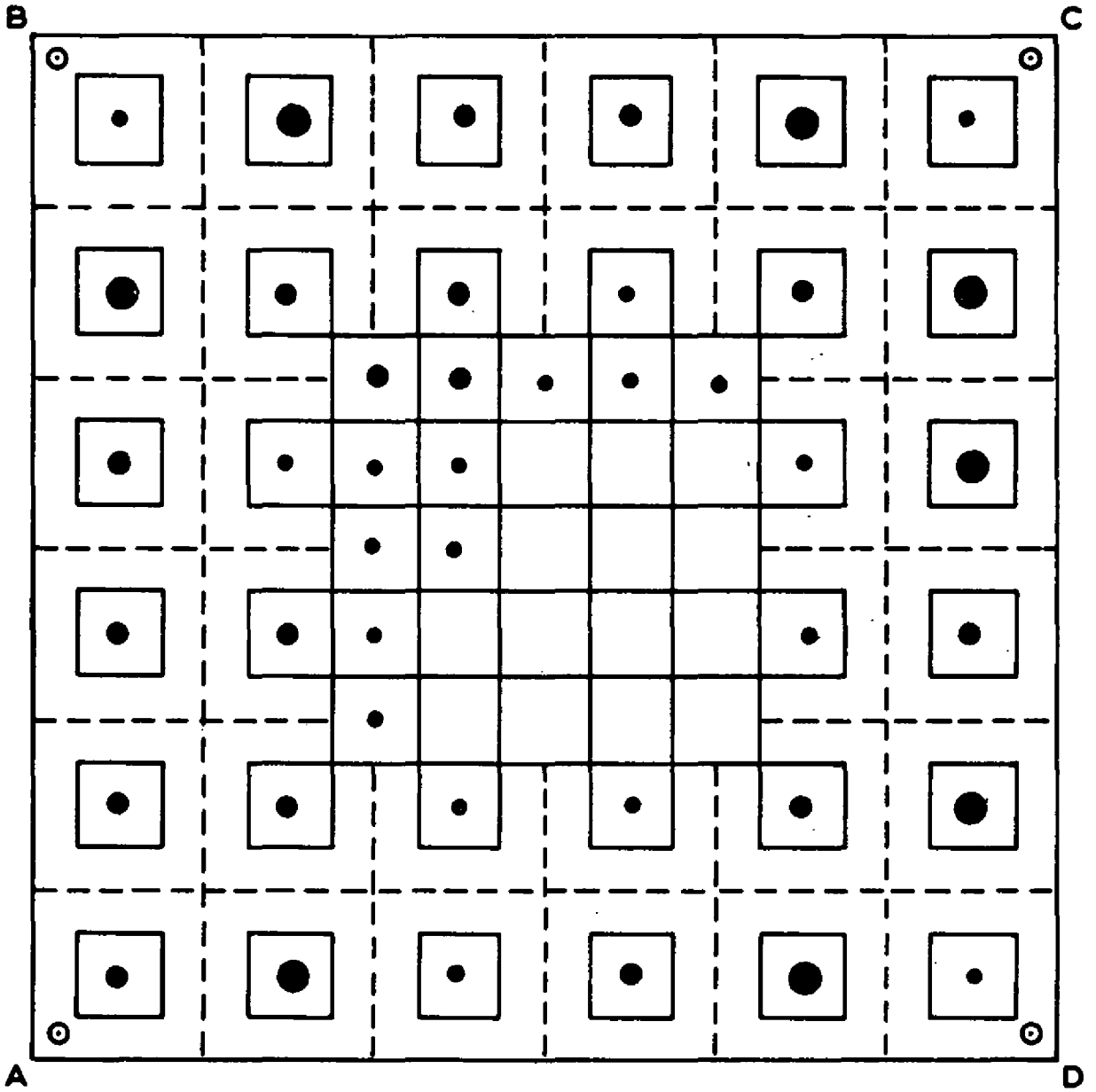


Make R

Type CONVENTIONAL, PENDENT

Level 2 ft.

Distribution number 20a.

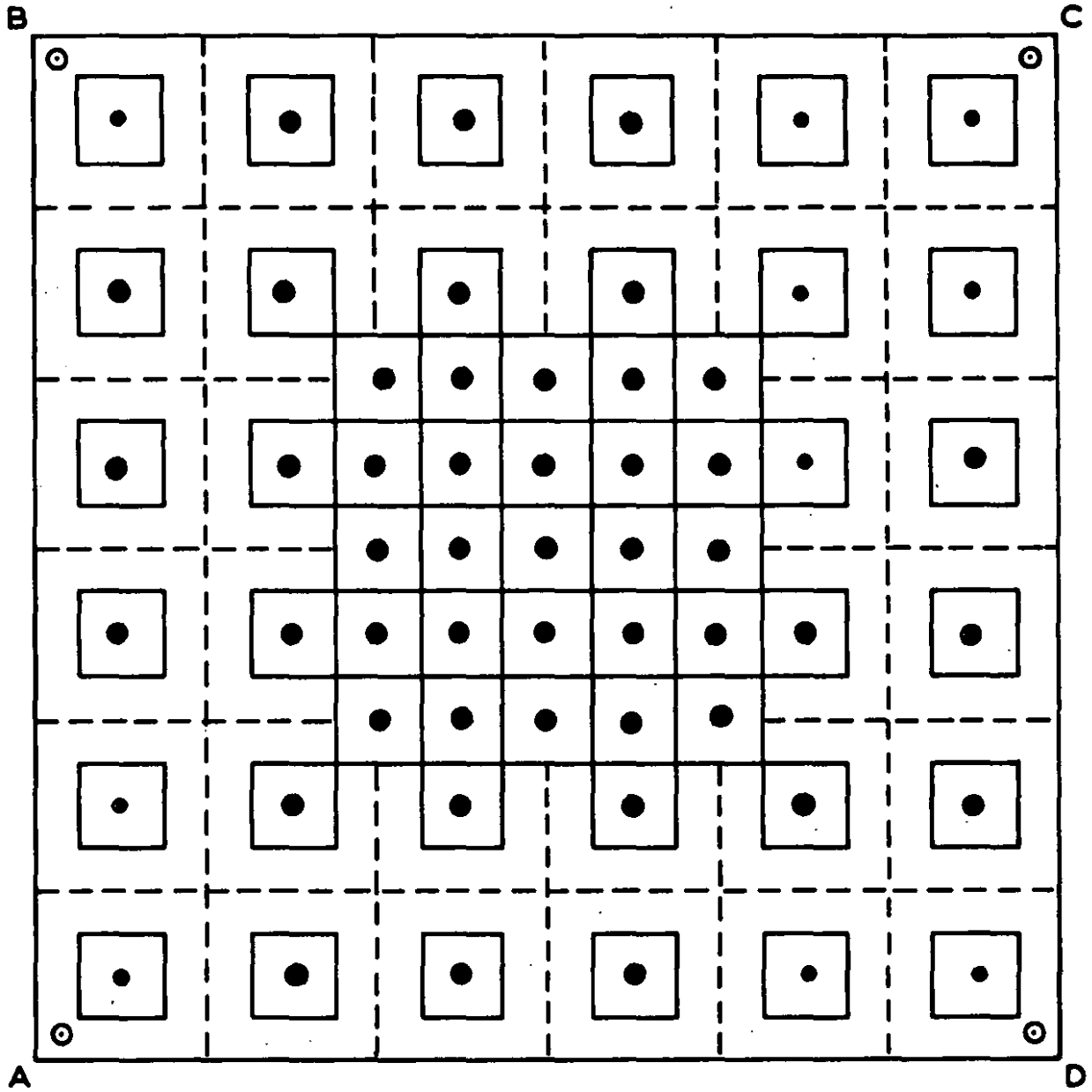


Make R

Type CONVENTIONAL, PENDENT

Level 4 ft.

Distribution number 20b

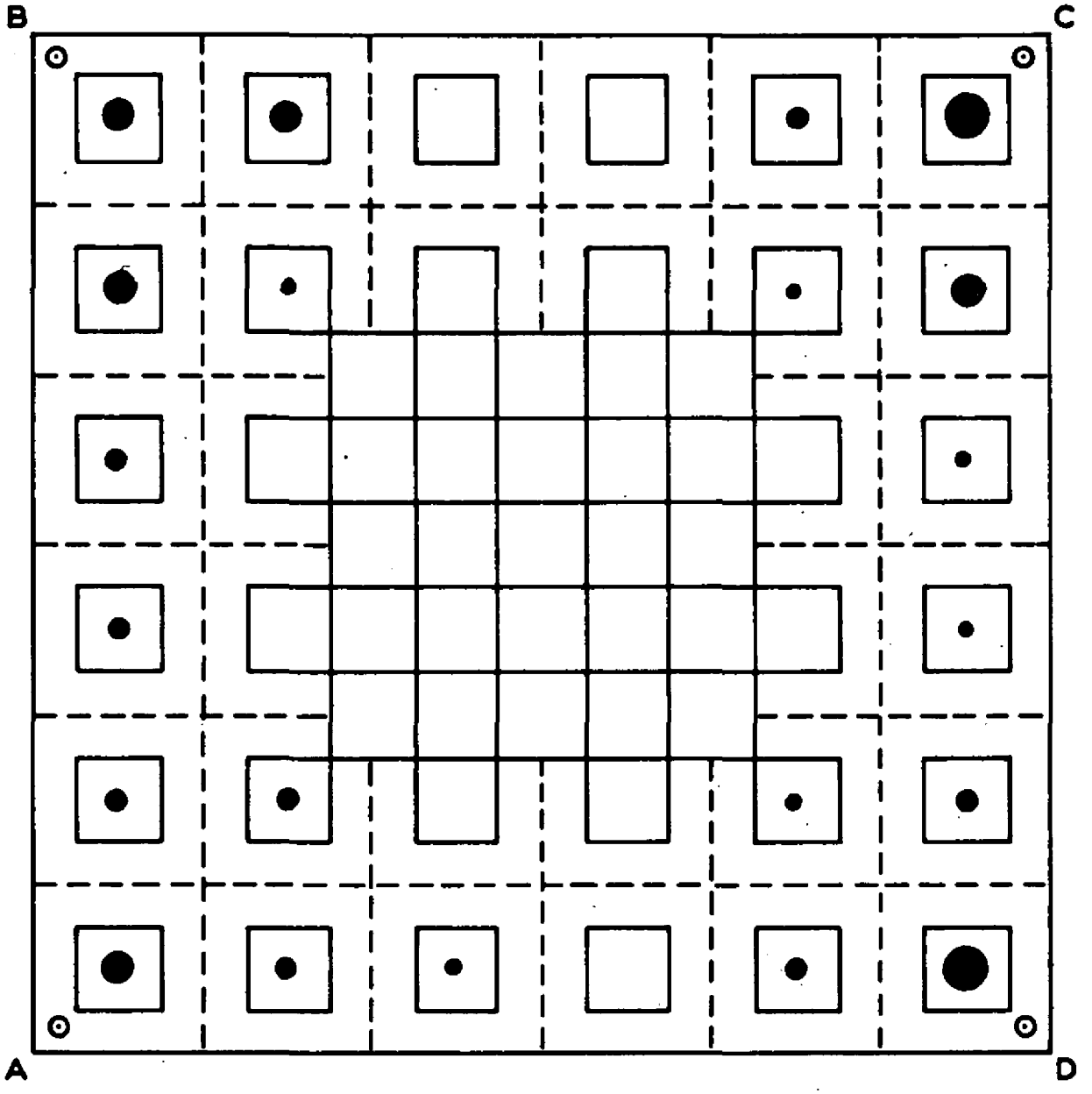


Make R

Type CONVENTIONAL, PENDENT

Level 12 ft.

Distribution number 20c.

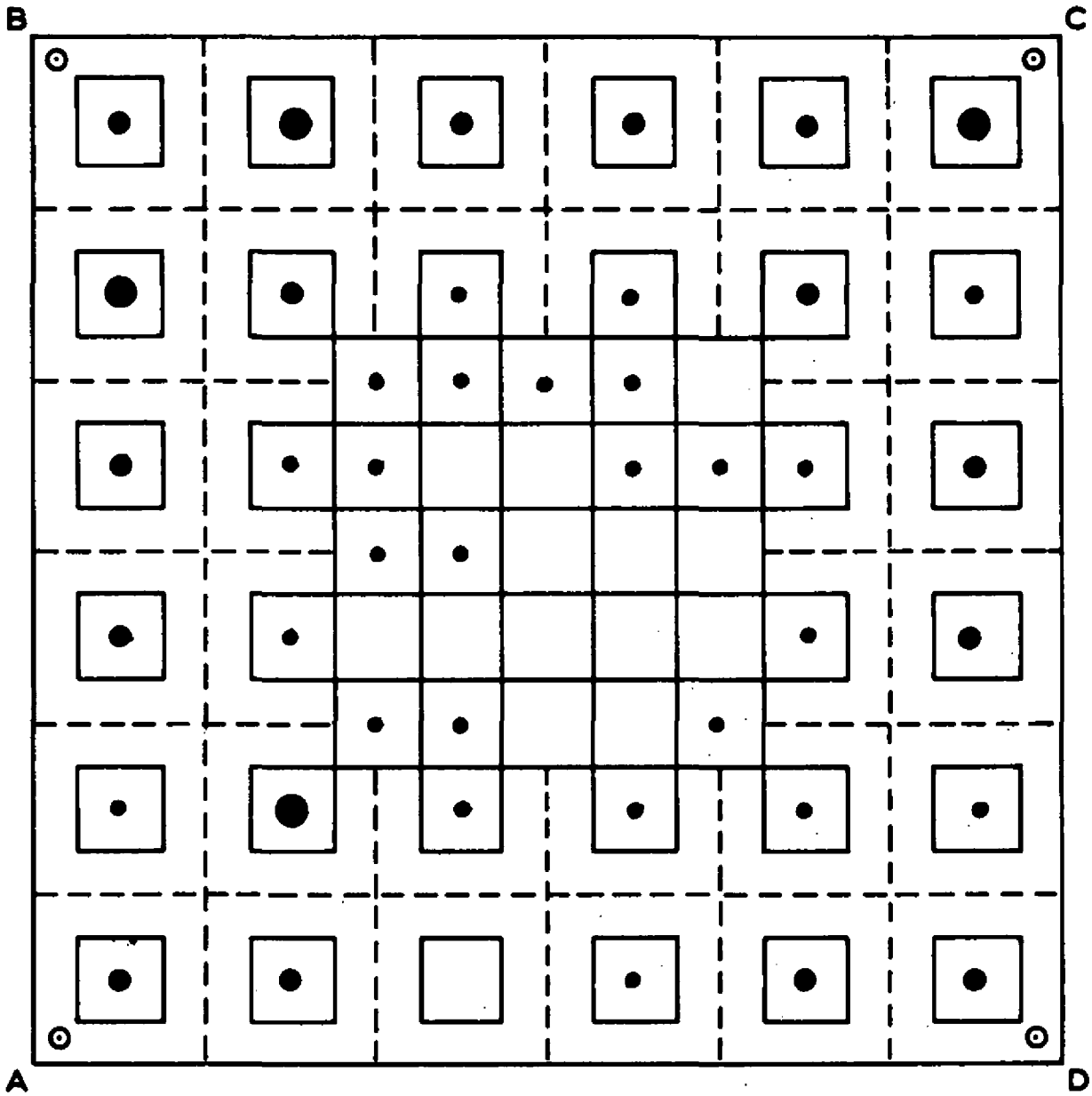


Make s

Type CONVENTIONAL, PENDENT

Level 2 ft.

Distribution number 21a.

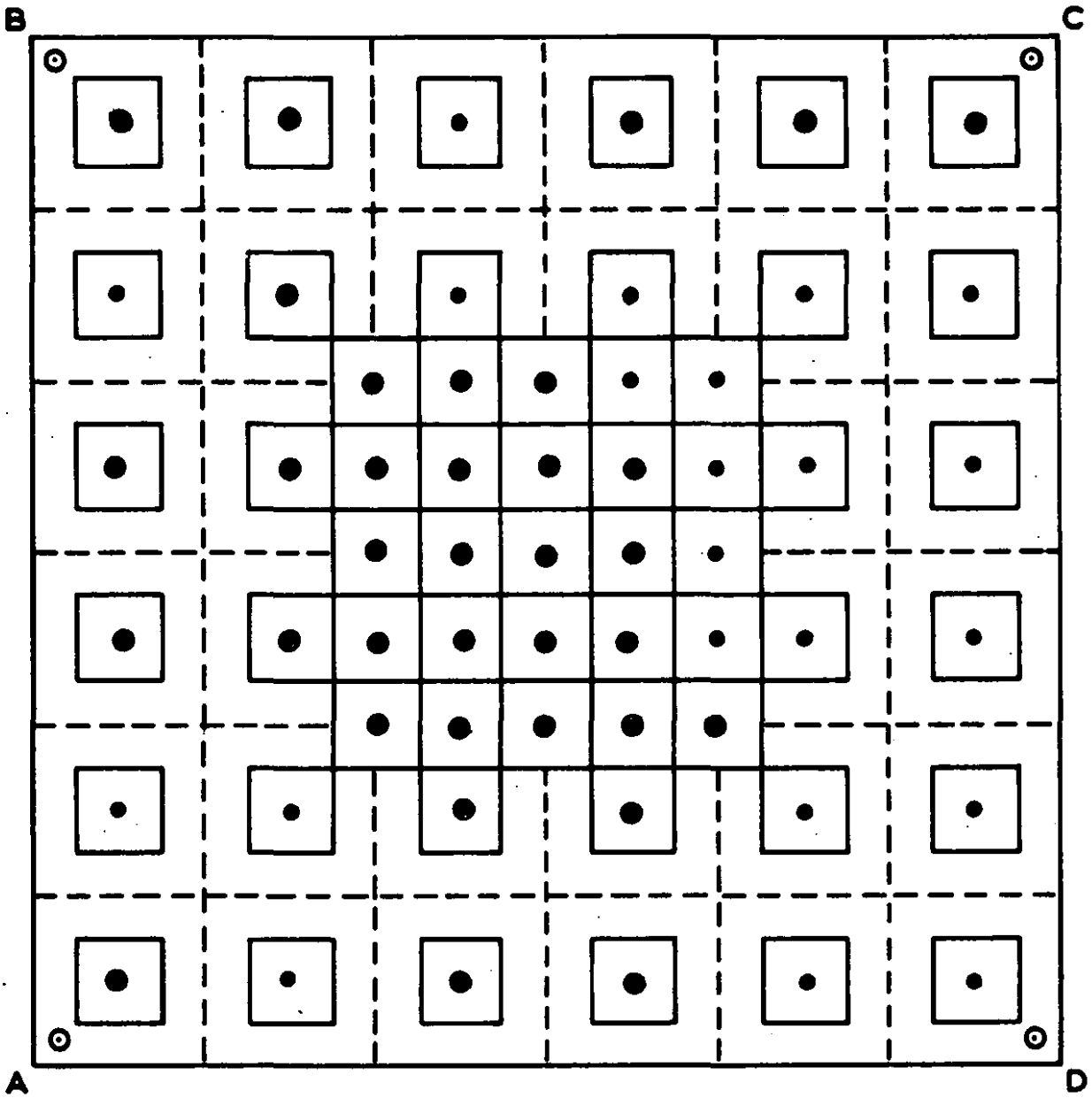


Make S

Type CONVENTIONAL, PENDENT

Level 4 ft.

Distribution number 21b

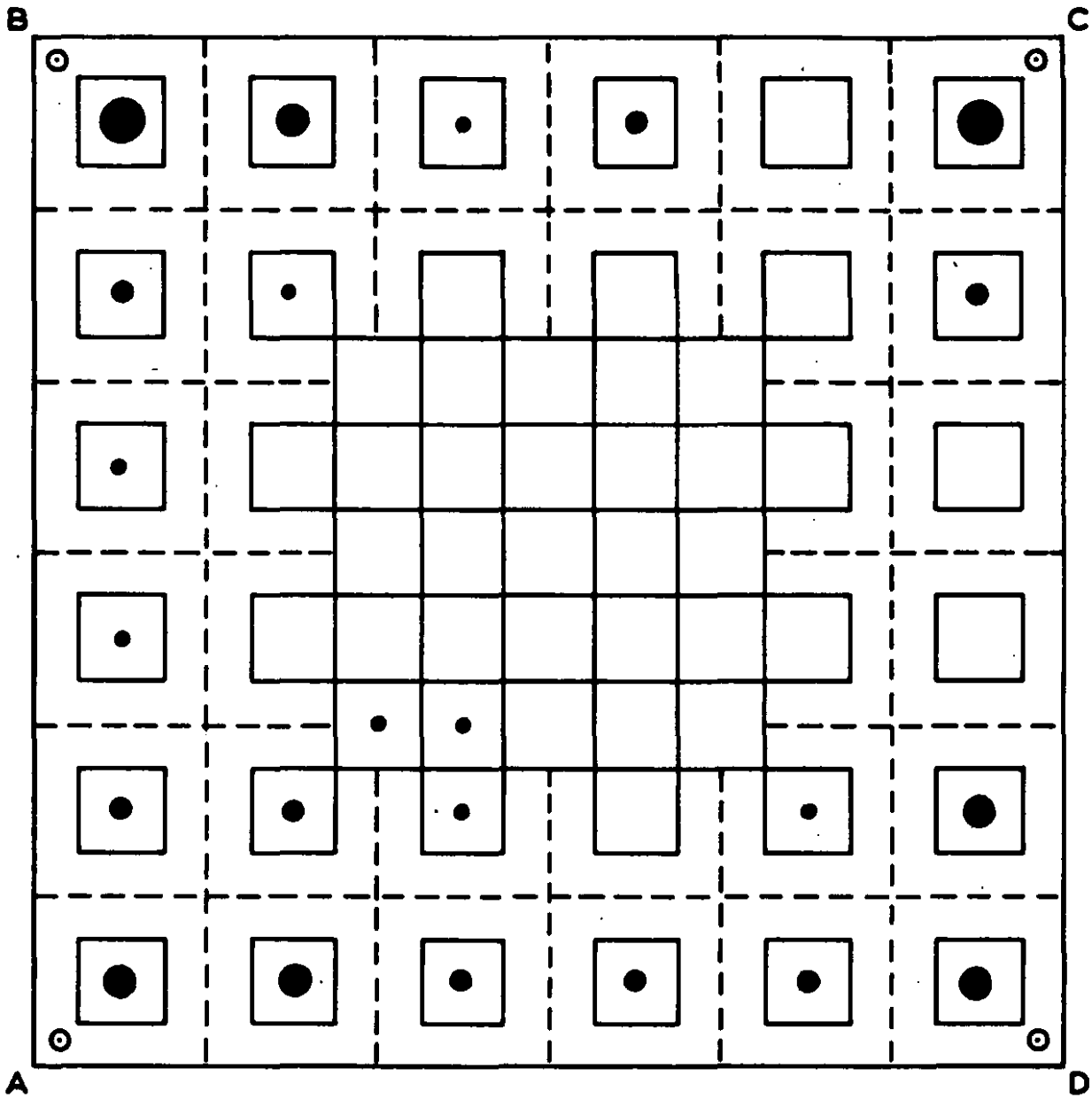


Make 8

Type CONVENTIONAL, PENDENT

Level 12 ft.

Distribution number 21c

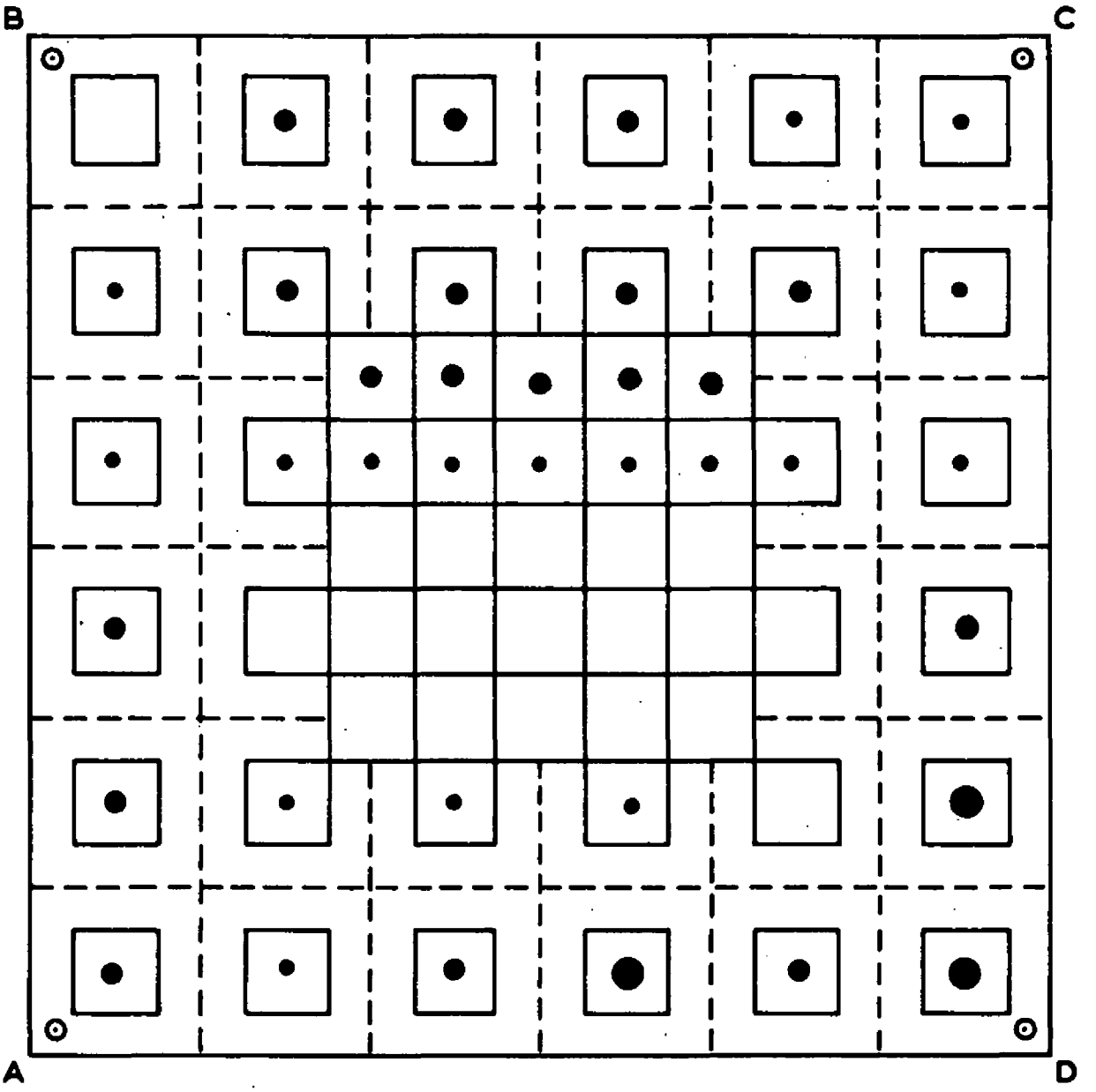


Make T

Type CONVENTIONAL, PENDENT

Level 2 ft.

Distribution number 22a.

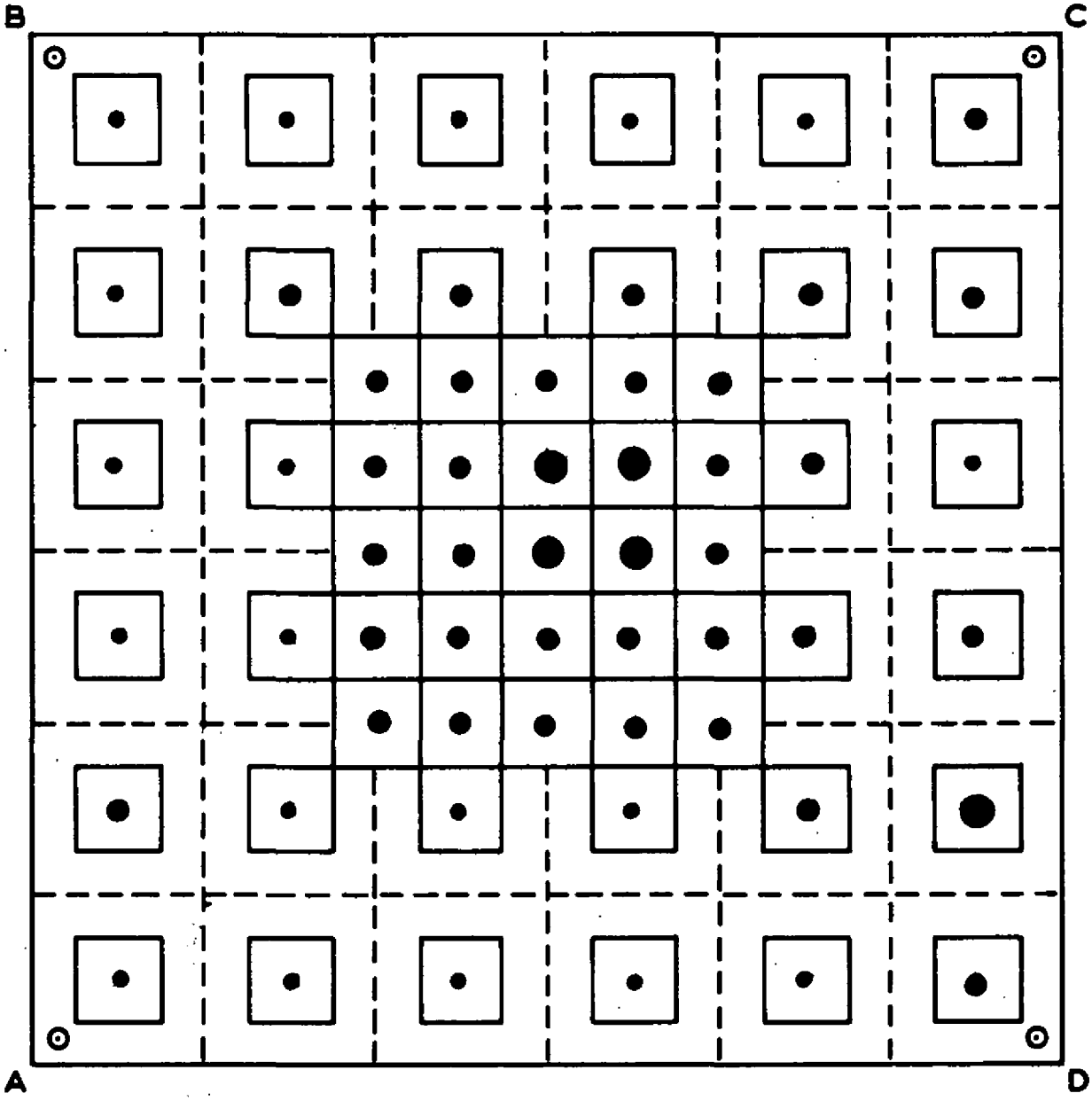


Make T

Type CONVENTIONAL, PENDENT

Level 4 ft.

Distribution number 22b

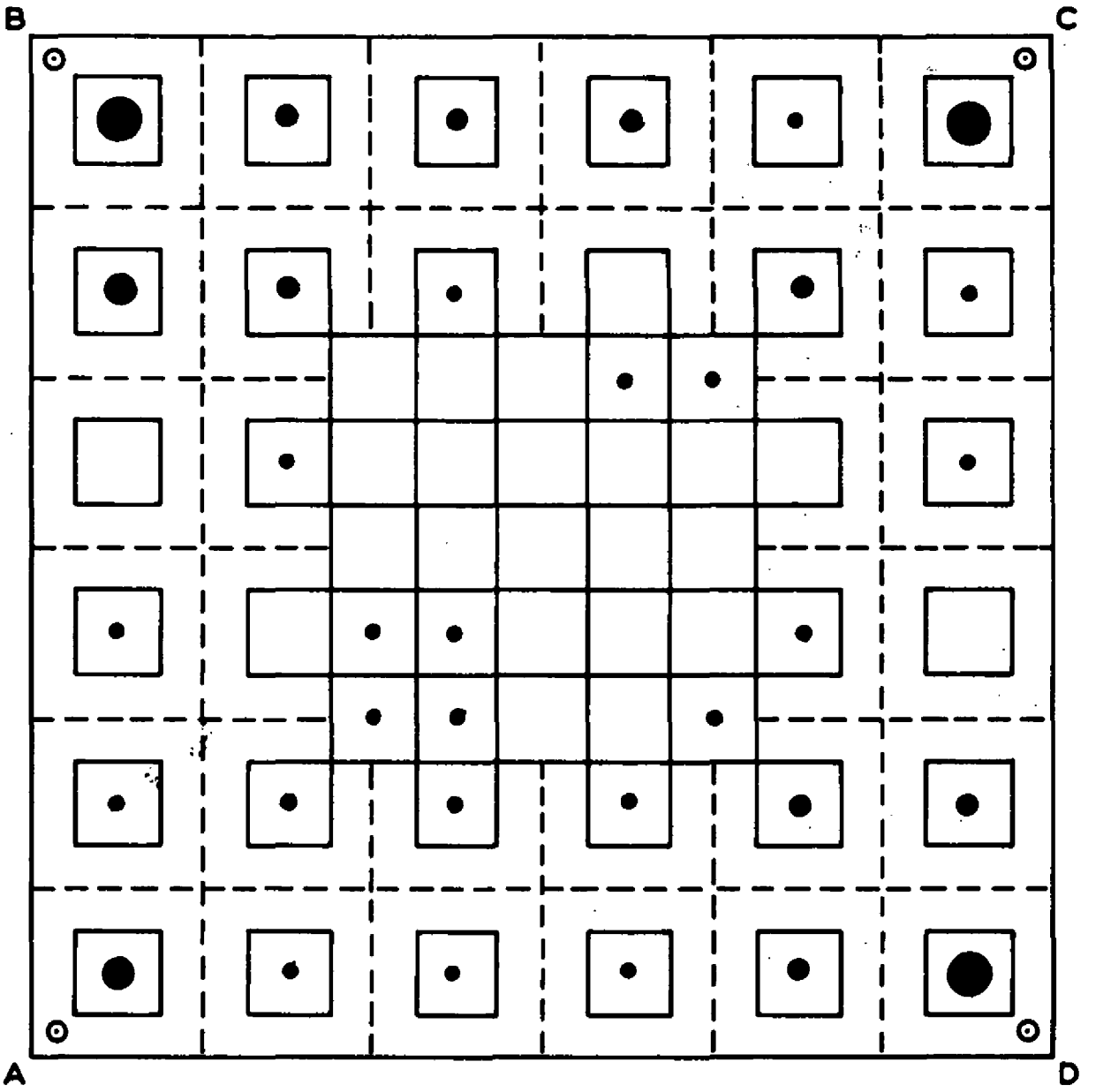


Make T

Type CONVENTIONAL, PENDENT

Level 12 ft.

Distribution number 22e.

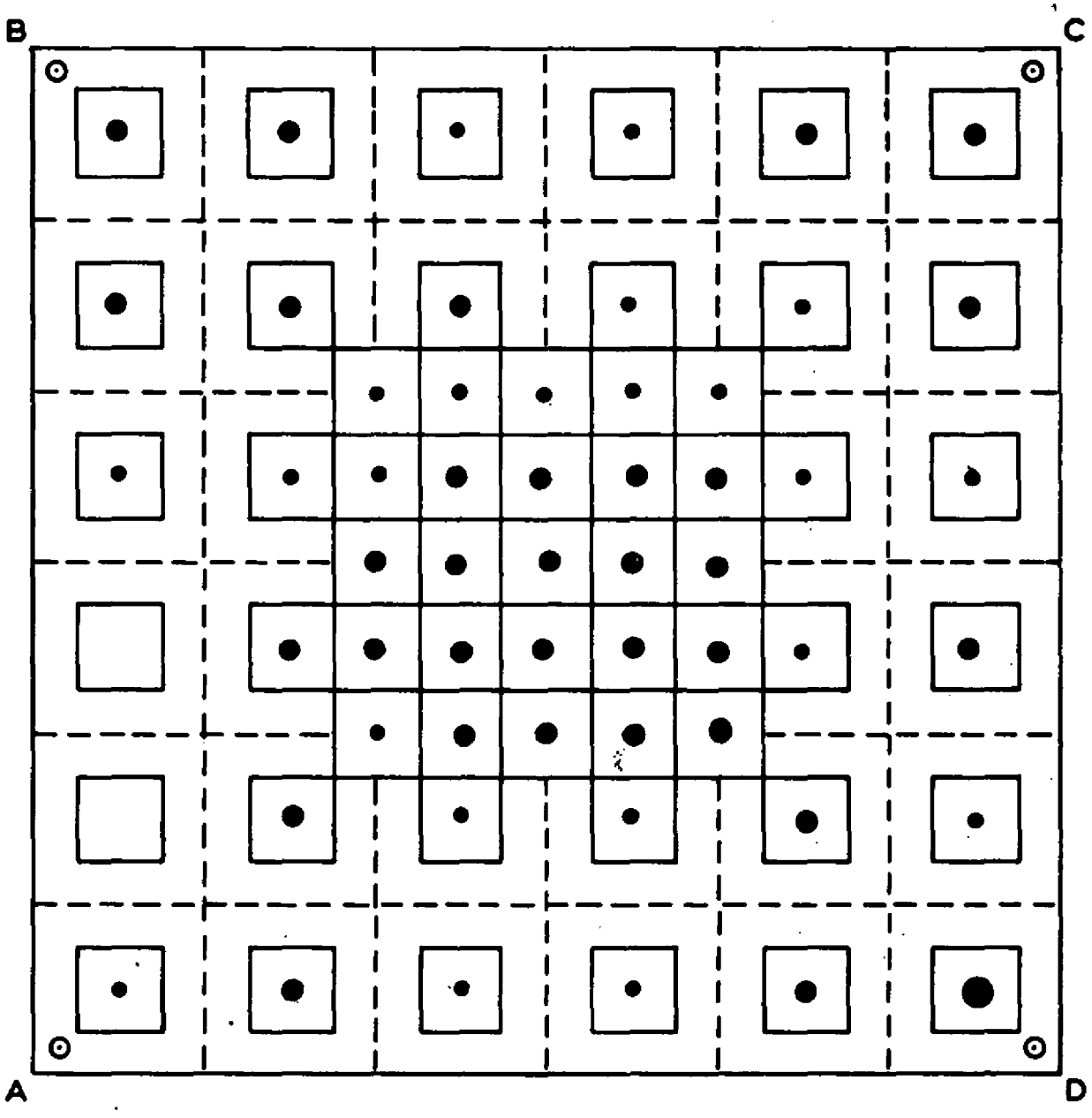


Make 'Q' model 3

Type CONVENTIONAL PENDENT.

Level 2 ft.

Distribution number 23a.

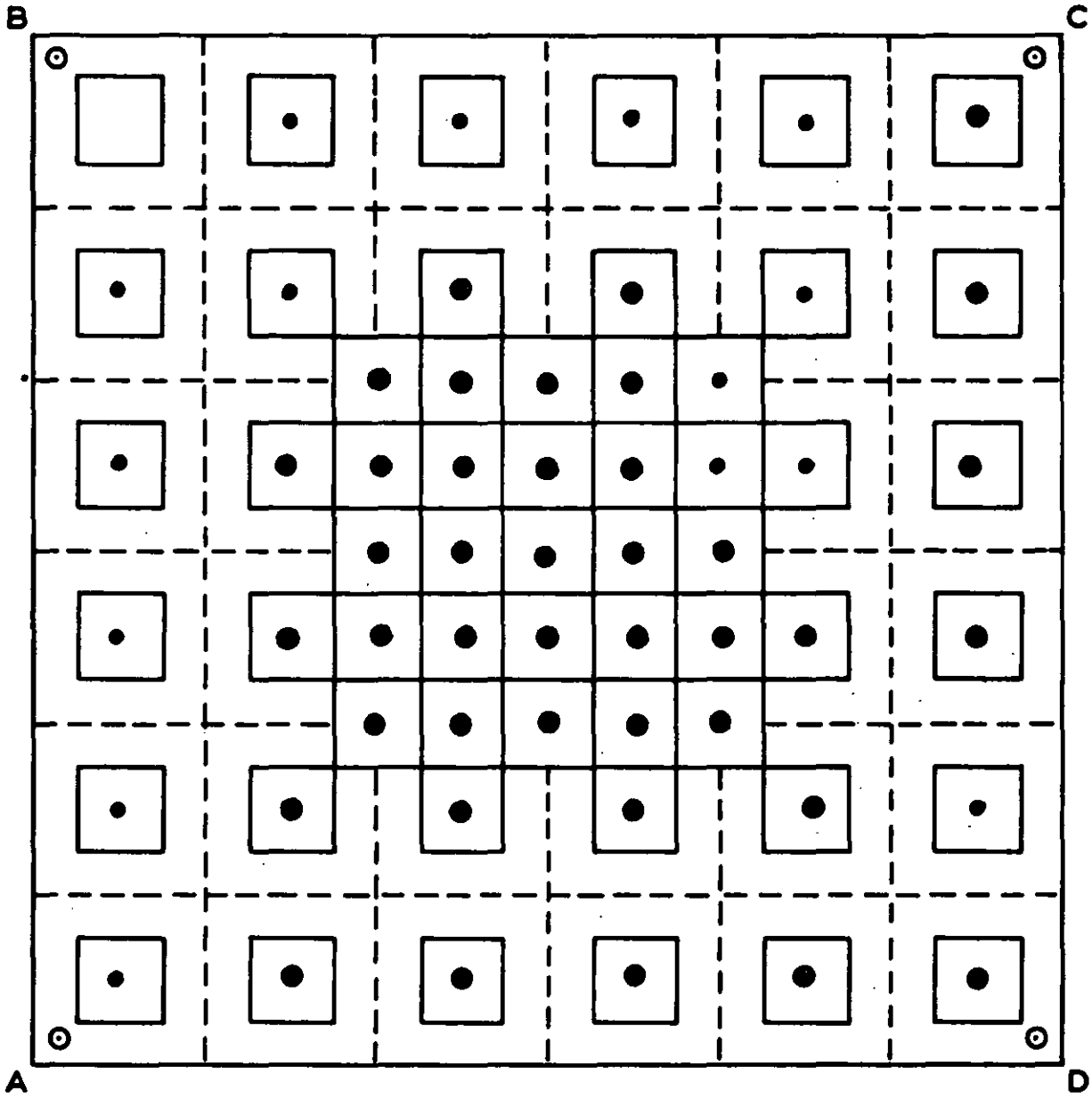


Make 'Q' model 3

Type CONVENTIONAL, PENDENT

Level 4 ft.

Distribution number 23b.



Make 'Q' model 3

Type CONVENTIONAL PENDENT

Level 12 ft.

Distribution number 23c.